POWER PLANT ENGINEERING

Established Over 30 Years

VOL. XXX | CHICAGO, APRIL 1, 1926 | No. 7

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Published on the 1st and 15th of each Month by the Technical Publishing Co., 537 So. Dearborn Street, Chicago
New York Office, 150 Nassau Street

Subscription price $2.00 a year in the United States and possessions. Canada $2.75 a year. Other countries $3.50 a year. Single copies 15 cents.

Copyright 1926, by Technical Publishing Co.

Entered as second class matter May 1, 1908, at the Post Office at Chicago, Illinois, under the act of March 3, 1879.

Member, Associated Business Papers, Audit Bureau of Circulations

Circulation of this Issue 23,340

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Down Where the Breakers Roll

SITTING ON A beautiful sandy beach where the great, green breakers, each one capped with its plumes of white, roll majestically in with apparently exhaustless energy, have you ever seen those breakers throw out on the beach any such mass of junk as that pictured above? Neither have we! If we had, we'd think that Father Neptune's rolling stock needed repairing—or else that we had "delirious trimmins." Nevertheless, that pile of junkman's delight was thrown out by breakers and we dare you to call us liars! Sure thing—by the coal breakers in a large central station.

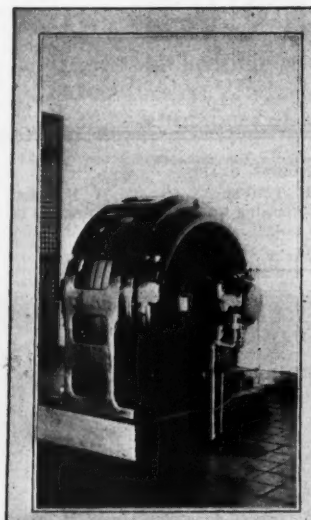
Think what that brake-wheel or that nice piece of coiled spring might do to a big, hungry stoker, if they once got into the coal bunker, to say nothing of the bolts and structural steel. But they didn't, as you see. And that pile is only part of the junk that the breakers threw out; you ought to see the mine timbers and the rocks that came out too. Samples of the latter appear at the right.

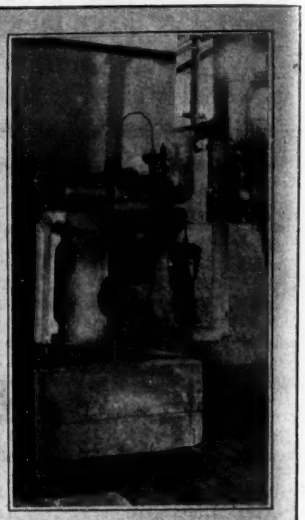
This pile of tramp metal is the accumulation of about 2½ mo. of last year at Crawford Avenue station. At the time the photo was taken for the Pennsylvania Crusher Co., the plant was burning about 30 carloads of coal a day.

"TRY A VANILLA WAFER," suggested the head baker of the National Biscuit Co.'s plant at Philadelphia, as he brought into the manager's office, where we were visiting, a sample tray laden with inviting rows of crisp biscuits and crakers, fresh from the ovens. The manager tasted one, then inspected it for color and texture. "Those are very good," he said, finally. "Make two million." In getting out such an order of biscuits, which is only a small proportion of the factory's product, many interesting problems are encountered, not the least of which is the power problem. To solve this problem, the company's new power plant, as described in this issue, was constructed.

New National Biscuit Co. Plant at Philadelphia

New Power Plant of 684 Boiler Horsepower Capacity Serves New Eight Story Bakery in Philadelphia with Electricity, Steam and Refrigeration for All Purposes





SEVERAL YEARS ago, in September, 1923, to be specific, there was published in this magazine a description of a new power plant for a large bakery at Buffalo, N. Y. This plant, which was that of the National Biscuit Co., was an exceptionally fine example of industrial power plant construction and reflected a very careful consideration of all the factors involved in this type of plant design.

In this article we are again describing a National Biscuit Co. power plant, this time the one for the enlarged bakery at Philadelphia, and the reader who recalls the article on the Buffalo plant will recognize many points of similarity between the two plants. This is only to be expected, since both plans were designed under the direction of D. M. McKelvey, consulting engineer of the company, and are built for the same kind of service.

Previous to the construction of the eight-story addition about 150 kw. was generated by belted machines, the rest was purchased from the local public service company, while steam for heating and process work was furnished by their own boiler plant. With the erection of the new addition, however, it was decided to incorporate in the expansion program designs for a complete power plant to furnish all electricity, steam, water, refrigeration and other necessary commodities used in the new bakery. This plant has now been completed and is in operation.

While there are, as has been indicated above, many points of similarity between the Philadelphia and Buffalo plants, because of space limitations at Philadelphia, a somewhat different arrangement of equipment was necessary. The engine room, for instance, had to be located on the first floor of the regular factory building, a fact which did not give much head room and made impossible the installation of an overhead crane.

The general arrangement of equipment and of the plant is shown in the accompanying drawings, the boiler room occupying one end of the layout and the engine room and pump room the other. The pump room is directly be-

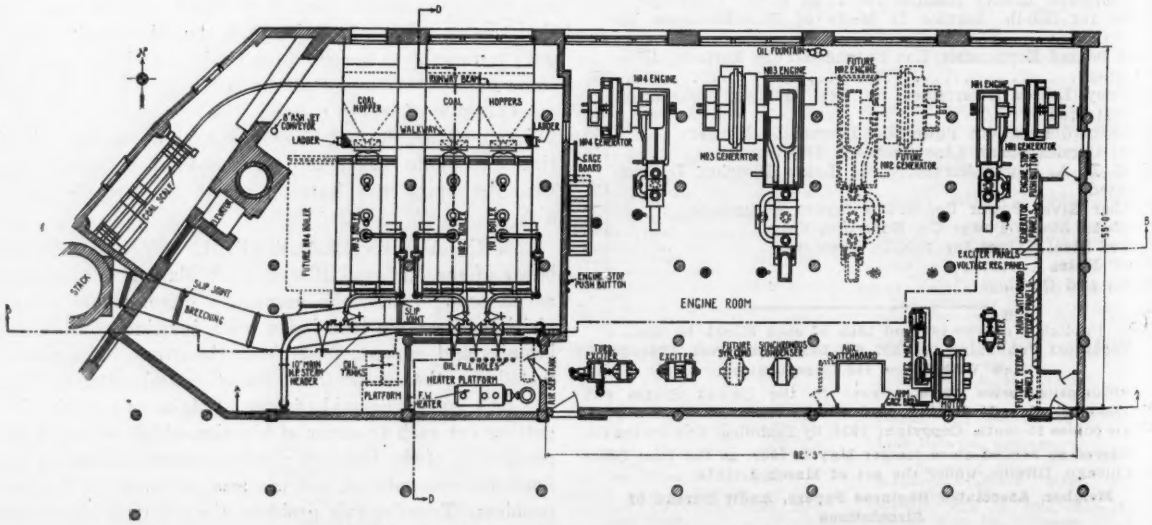


FIG. 1. PLAN OF THE PLANT AT THE ENGINE ROOM LEVEL

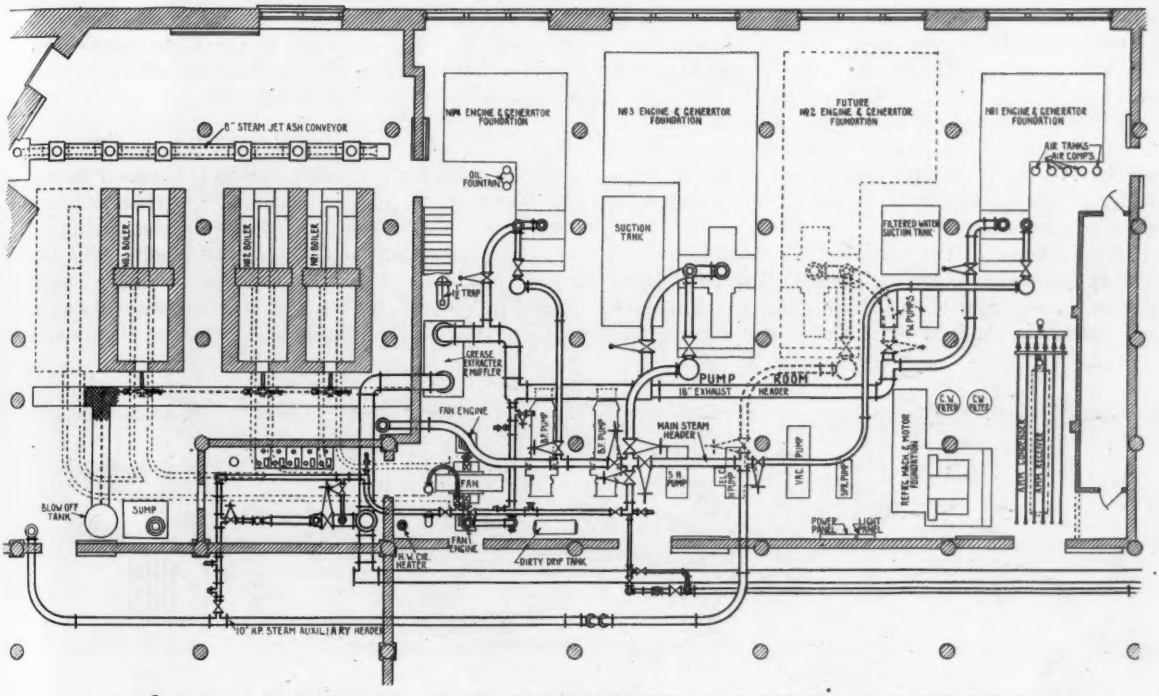


FIG. 2. LAYOUT OF EQUIPMENT AND ARRANGEMENT OF PIPING AT THE BOILER ROOM FLOOR LEVEL

low the engine room and on the same level with the boiler room floor.

As in the Buffalo plant, an atmosphere of neatness prevails throughout. The engine room, in spite of the low ceiling height, is attractively designed and well illuminated by large windows occupying the entire outside wall. The walls are painted a light cream color and the floor is of square red tile.

Mechanical Features

Coal is delivered by railroad cars to a track hopper and dumped directly into a storage bin adjacent to the boiler room. The coal used is of an excellent grade, known as Maderia Hill, and is a washed Pennsylvania bituminous with a heat value of 14,000 B.t.u. per lb. and containing about 9 per cent ash. It is taken from the storage bin and delivered directly to bins feeding the stoker hoppers by a Shepard cage-operated electric hoist equipped with a clam-shell bucket of ¾ cu. yd. capacity and operating on an overhead monorail track. An automatic scale installed in one section of the monorail provides a means of weighing the coal before its delivery to the stokers. As will be seen from Fig. 8, which shows a cross section of the boiler room, the coal hoppers are built directly above the firing aisle, being in effect extensions of the stoker hoppers.

Boiler Equipment

Steam is generated at a normal pressure of 155 lb. gage with 100 deg. superheat in three 228 hp. Babcock & Wilcox Co. longitudinal drum boilers, equipped with Combustion Engineering Corporation Type E stokers, and Foster superheaters made by Power Specialty Co. As may be noted from the plan view, provision has been made for the installation of a fourth boiler if that becomes necessary. Each boiler is fitted with the following accessory equipment: Diamond soot blowers (5 units per boiler), S-C feed-water regulators, Reliance water columns, Cadman blowoff valves and Consolidated safety valves. Combustion is controlled automatically by the Engineer Co. system of control. This is a balanced draft system, in which the air supply and, therefore, the rate of combustion is governed according to the steam demand. A compensating steam regulator connected to the plant header actuates a valve which controls the steam supply to the fan engine. Any variation in header pressure thus produces a corresponding variation in the speed of the forced draft fan and, therefore, in the rate of combustion. At the same time, the draft pressure above the fuel bed is regulated through the agency of a furnace pressure regulator and the uptake damper.

Forced draft for all three boilers is supplied by a Sirocco fan, driven by either of two vertical engines, one at each end of the shaft. Coupling flanges are provided between each engine and the fan shaft, so that in case it

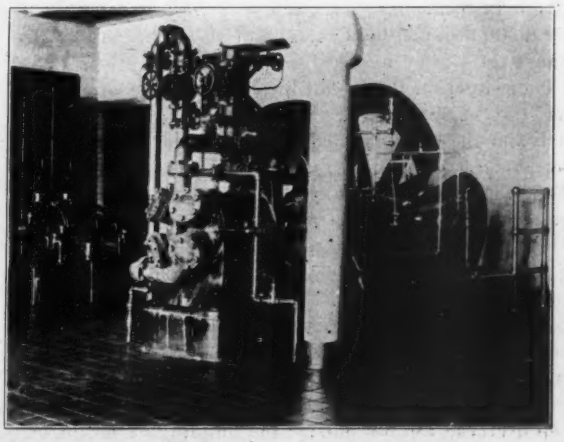


FIG. 3. THE 55-T. REFRIGERATING MACHINE IS OPERATED BY A SYNCHRONOUS MOTOR

becomes necessary to change the drive from one engine to the other, it can be accomplished in a few minutes time. The entire fan installation was furnished by the American Blower Co.

The air for combustion is supplied through ducts installed below the boiler room floor, the arrangement being shown in Fig. 2. A 150-ft. radial brick stack, 6 ft. in diameter at the top and 10 ft. at the bottom, removes the products of combustion.

Draft pressures in the wind box, in the furnace and in the uptake are indicated by Bailey Multipoint draft indicators on the front of each boiler. An accurate check on combustion is obtained by means of a number of recording and indicating instruments. The CO_2 content of the flue gas is measured and recorded by three Hays CO_2 recorders. Flue gas temperatures are recorded by Foxboro recorders, one for the uptake from each boiler. The degree of superheat in the steam is likewise recorded by Foxboro instruments. Stack temperatures, as a rule, run around 500 deg. and the CO_2 content of the flue gas usually averages 11.5 per cent.

These instruments are all installed in the engine room, where they can at all times be observed by the engineer on watch and the readings used in keeping the log. The CO_2 recorders are mounted on the west wall close to the boilers with which they are connected. The temperature and pressure recording and indicating instruments are all grouped on one gage board also located against the west wall of the room. A General Electric Co. electrically operated steam flow meter, equipped with indicating, integrating and recording instruments, occupies two of the five panels which make up this gage board. A view of this board is shown in Fig. 7.

Ash is removed from the ashpits by hand and carried to an overhead ash bin outside the building by means of a Victor steam jet conveyor. With this system the ash is hoed into the firing aisle and introduced into the conveyor line through a circular opening in the floor. With the relatively small amounts of ash to be handled in a plant of this size, a system such as this affords a simple solution to the problem of ash removal.

Feed Water System

Feed water for the boilers, which is obtained from the city mains, is brought to a temperature of from 212 to 218 deg. in a Webster open type feed-water heater, and delivered to the boilers by either of two pumps. The latter are duplicate units of the compound, duplex, outside packed piston type, made by the Warren Steam Pump Co., and equipped with Mason pump governors. The water is

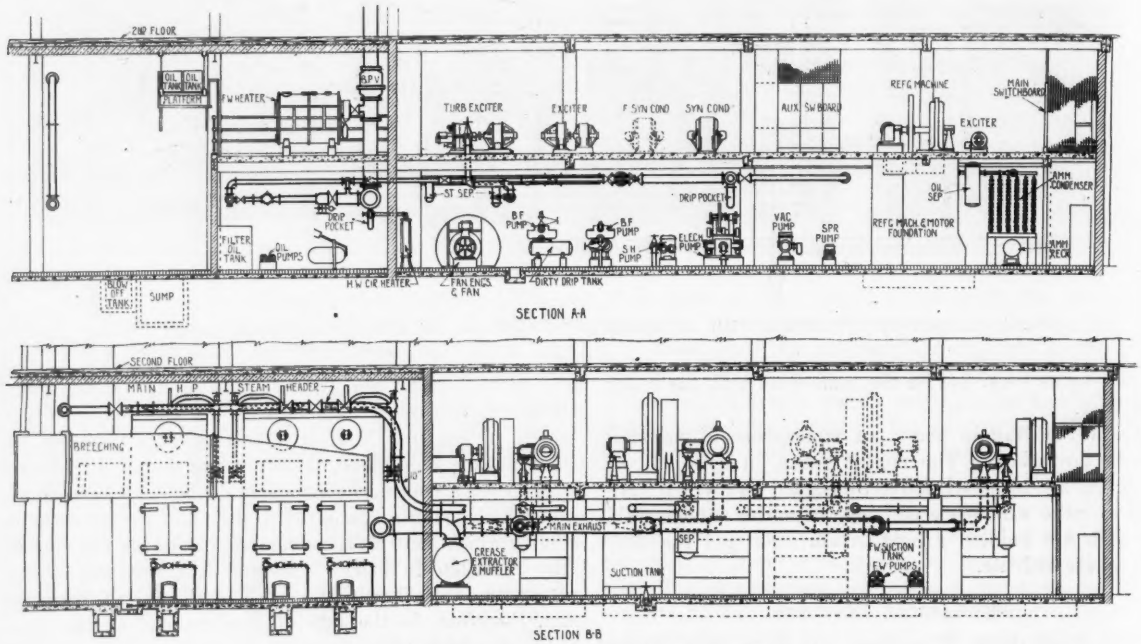


FIG. 4. LONGITUDINAL SECTIONS THROUGH THE PLANT

treated in the boilers with Liberty boiler compound which seems to give good satisfaction. It is introduced in the boiler drum by means of a small Warren steam pump with the piping arranged so that each boiler may be fed separately.

In addition to the main feed-water lines to the boilers, an emergency system of feed is associated with the blowoff system, so that, in case of damage to the regular feed system, the boiler can be fed through the blowoff valves. All feed water is heated by exhaust steam.

A sump pump is installed in the boiler room behind the boiler to pump drainage water from the sump, which is below the sewer level, into the sewer. This unit, made by the Chicago Pump Co., is electrically operated and automatically controlled by a float switch.

Uniflow Engines Installed as Prime Movers

All electrical energy used throughout the bakery is generated by three 440-v. General Electric Co. alternators, each driven by a Skinner Universal Uniflow engine operating non-condensing against a normal back pressure of 3½ lb. Two of these units are 250-kv.a. units operating at 200 r.p.m., while the third is a 500-kv.a. machine operating at 120 r.p.m. Ordinarily, the day load is carried by the large

engine alone, but at night, when the load is light, this unit is shut down and one of the small units operated. In case of trouble with the large unit during the day, the load can be carried, if necessary, by both of the small machines operating together. Or, if the day load becomes excessively large, too large for the large machine operating alone to carry it, the large unit, together with one small unit, may be run. So all conditions can be met and a suitable factor of safety provided against shut down.

Each engine is fitted with a Strong, Carlisle and Hammond automatic engine stop valve operated by an overspeed trip on the engine shaft, or by means of push buttons located on the wall of the engine room near the exits.

Lubrication of the engines is normally effected by means of a Bowser pressure oiling system. This consists of an oil storage tank and filter, together with three motor driven oil pumps. Two of the pumps are used to supply engine oil and the third only for cylinder oil. This equipment is installed in the basement. In addition to this

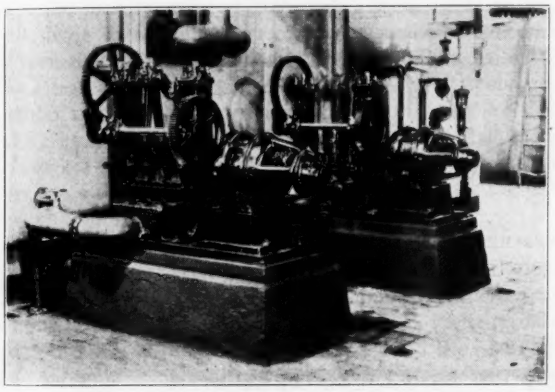


FIG. 5. TWO ELECTRICALLY DRIVEN TRIPLEX PUMPS SUPPLY FILTERED WATER TO THE BAKERY

system of lubrication, each engine, of course, is also fitted with the usual lubricating system provided on Skinner engines. This can be cut in at a moment's notice if something should happen to the Bowser system.

Another interesting feature is the S-C system of drainage control which is installed. This system, developed for the purpose of trapping and separating water from steam, consists of a drip pocket or tank with a special control valve connected to the outlet. This valve is operated by pressure from a generator and can be adjusted so as to maintain a constant level in the tank. If condensate flows into the tank at all times, the flow from the tank will be in the same proportion. The generator which actuates the regulating valve is built on the same principle as that used on the S-C type of feed water regulator. A view of one of these drainage control systems is shown at the left in the group of photographs at the head of this article.

Four of these units are installed, one for each steam separator in the main steam line to each engine, and one serving the steam jackets on the engines. Additional S-C traps are provided for draining the steam mains.

The main steam line arrangement is simple and direct. Steam is taken from the boilers through 5-in. headers which connect into the main 10-in. engine room header. The latter is arranged in the form of a rectangular loop, one side of which passes under the engine room floor to the engines while the other is installed entirely outside of the power plant in the factory building. The main exhaust piping is arranged, as shown in the acompanying drawings, a grease extractor being interposed between the engines and the feed water heater to prevent oil from entering the boilers.

Electrical Features

Excitation for the main units is furnished by either of two separately driven General Electric exciter sets. One

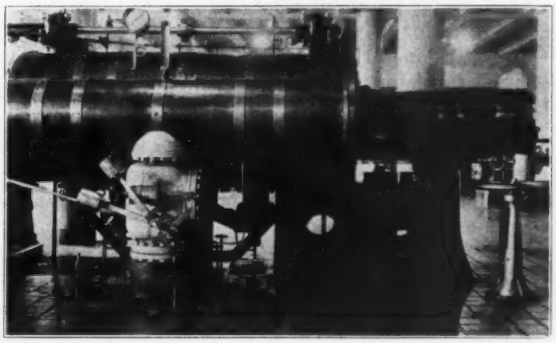


FIG. 6. A CLOSE-UP OF ONE OF THE AUTOMATIC ENGINE STOP VALVES WITH WHICH ALL ENGINES ARE EQUIPPED

of these is a 75-kw., 1200-r.p.m., 600-amp., 125-v., direct current generator, direct connected to a 115-hp., 440-v., 60-cycle induction motor. The other is a steam driven unit consisting of a 75-kw., d.c. generator, direct connected to a Curtis non-condensing turbine. Under ordinary operating conditions, the motor driven unit is the only one used, the turbine driven machine being provided for emergency use only and for starting up the plant.

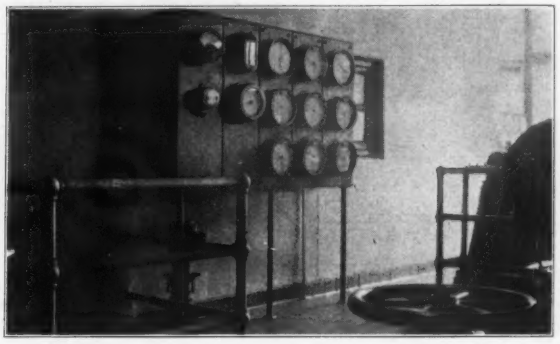


FIG. 7. THE METER BOARD IN THE ENGINE ROOM

In addition to the exciters for the main unit, there is also a small 25-kw. exciter set, motor driven, to supply field current for the synchronous condenser and the synchronous motor driving the ice machine.

The synchronous condenser, referred to, is a G. E. unit rated at 500 kv.a., 440 v., 60 cycles, 900 r.p.m., provided for power factor correction purposes. The electrical load in the bakery consists largely of induction motors and without the use of some corrective device, the power factor of the system would be low. With the synchronous condenser it is maintained at 85 per cent without difficulty.

The synchronous motor driving the ice machine is a 105-kv.a. G. E. machine, and although it aids in raising the power factor, it has not enough capacity to bring it up to the value demanded without the aid of the 500-kv.a. condenser.

Two separate switchboards are provided, the main

board consisting of 19 panels and an auxiliary board of 3 panels for controlling the synchronous motors and their exciter. The panels of the main board are arranged as follows:

1—No. 1 engine generator (250 kv.a.)
2—Blank (for future No. 2 generator)
3—No. 3 engine generator (500 kv.a.)
4—No. 4 engine generator (250 kv.a.)
5—75 kw. motor driven exciter
6—75 kw. turbine driven exciter
7—Tirrill regulator panel
8-19—Feeder panels

A connection is provided between the auxiliary board and the main exciter bus on the main board, so that excitation for the synchronous motors can be derived from the main exciter bus if necessary.

The switchboards are of General Electric Construction throughout, made of marine finished, black slate, with manually operated oil switches installed on the rear of the panels. The voltmeter, frequency meter and synchroscope are mounted on a swinging bracket at one end of the board, so that these instruments can be seen from any position along the board.

Miscellaneous Features

The layout and arrangement of equipment in the pump room is shown in the basement plan in Fig. 2. Most of the pumps, for the factory water supply are located in this room as are also the various water storage tanks from which the pumps obtain their supply. The ammonia condenser and receiver for the 55-t. ice machine in the engine room above is installed in the southeast corner of the basement close to the ice-machine foundation, so as to facilitate piping connections. This ice machine is operated for about 12 hr. per day during the winter but during the summer it is used throughout the 24 hr. It is used to cool the various refrigeration rooms in the bakery, for water cooling and in some departments for air conditioning.

Filtered water to the bakery is pumped by the two Gould triplex pumps, shown in Fig. 5. Two city water service pumps are provided, one a Gould triplex unit driven by a 20-hp., 440-v. motor and the other a Warren duplex steam pump. A small Fairbanks, Morse pump, maintains the proper level of water in the sprinkler system and the pressure maintained by a large Worthington pump.

Compressed air for miscellaneous uses is furnished by three locomotive type Westinghouse air compressors mounted on the side of one of the engine foundations in the basement.

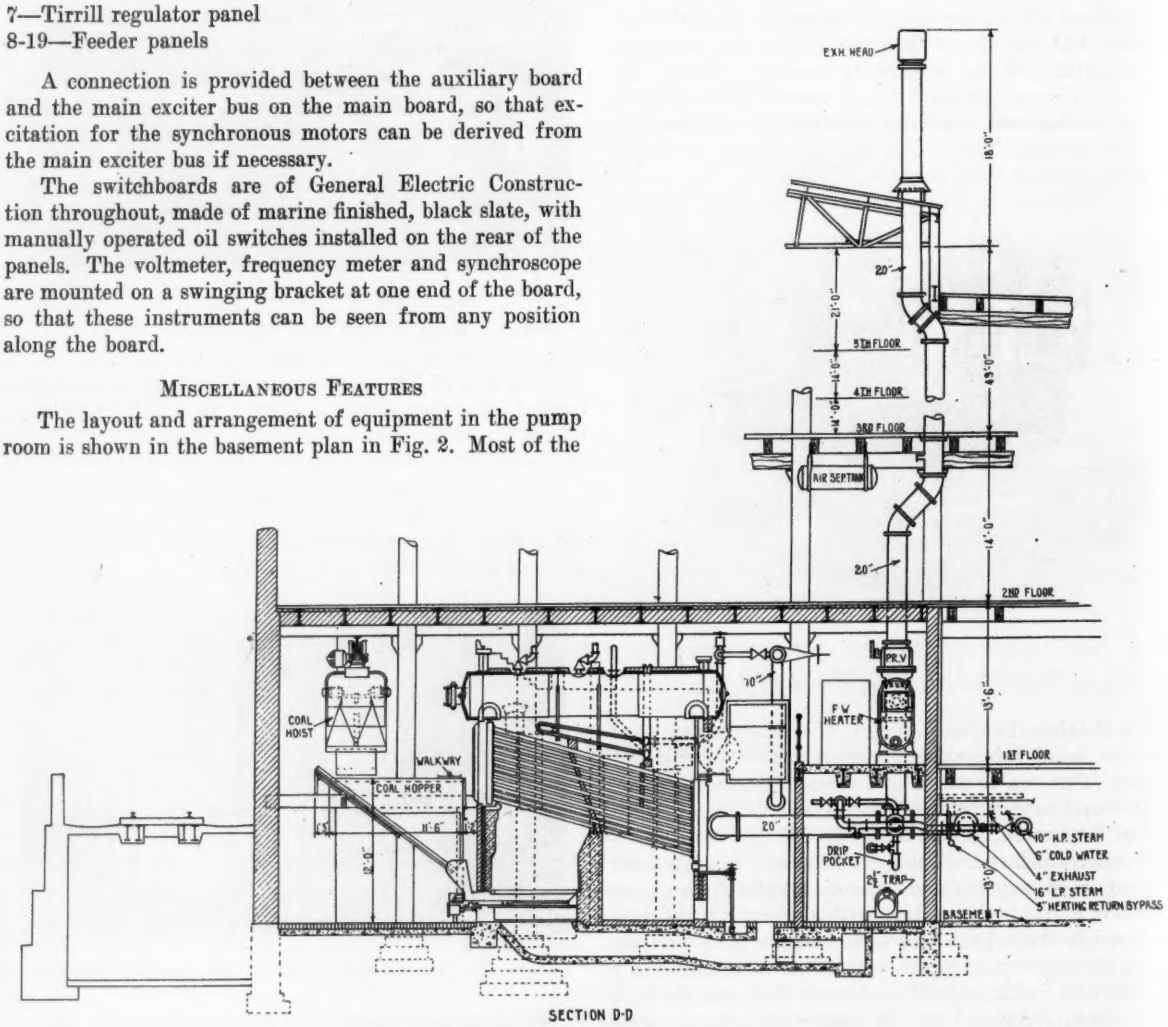


FIG. 8. A SECTIONAL VIEW THROUGH THE BOILER ROOM

While the layout of the plant had to be adapted to the existing building arrangement, it in no way interfered in securing an arrangement that is pleasing and satisfactory from an operating viewpoint. The operators' comfort has not been neglected. The plant is well lighted, well ventilated and excellent toilet facilities are provided for the employees. The engine room is supplied with fresh air by an exhaust fan which renews the air in the room every three minutes.

The plant is operated in three shifts under the direct supervision of W. A. Harmon, chief engineer. It was designed by D. M. McKelvey, the consulting engineer of the National Biscuit Co. at New York.

Corrosion Due to Magnesium and Calcium Salts

THIS CORROSION, WHICH IS DUE TO CERTAIN SALTS IN THE BOILER WATER, IS OFTEN DIFFICULT TO DETECT BECAUSE OF SCALE DEPOSITS. BY D. C. CARMICHAEL*

CORROSION WHICH takes place in boilers may be classified under two different headings; first that due to certain salts in the boiler water and second, that due to gases in the feed water. Of the two kinds, that which is due to certain salts as calcium nitrate, calcium chloride, magnesium chloride and magnesium nitrate is the type quite often overlooked by the operator. Any corrosion that might be due to dissolved gases in the feed water is usually taken care of in well vented open heaters, heating the water to such temperature as to drive off these gases.

Corrosion that results from the breaking up of magnesium or similar salts is the most serious on account of the extensive destruction that can take place to the boiler metal before the corrosion is discovered. Because the deposits, usually scale, shield these attacks there is, as a rule, little or no indication of the existence of this form of corrosion. Since all corrosion within boilers, caused by the action of high temperatures and pressures upon magnesium salts, is covered with scale deposits and as these salts are associated with soluble matter causing scale alone, a chemical treatment for the total precipitation of all scale-forming salts from the water within the boiler is the only real guarantee against it.

If not uncovered through mechanical or chemical means, such corrosion sometimes exposes itself through cracks in the scale, which develop immediately over the affected areas. This cracking of the scale is brought about by an increase in pressure, which develops in the corroding area through an increase in the volume of the corroding mass.

Magnesium chloride when present in a feed water, is usually in small quantities and often accompanied by considerable quantities of calcium carbonate (carbonate of lime), which for a time may prevent its corrosive action. This is shown by the following analysis of a well water:

Silica	17.0 parts per million
Iron and alumina	2.6 parts per million
Calcium carbonate	63.8 parts per million
Magnesium sulphate	12.8 parts per million
Magnesium chloride	10.0 parts per million
Sodium Chloride	2.5 parts per million
Total solids	108.7 parts per million

On evaporation a time comes when all the calcium carbonate has been made insoluble, and the magnesium chloride has become more concentrated. While magnesium chloride is a well behaved associate in the whole group of natural salts as they are contained in the water before entering the boiler, it becomes very active in causing corrosion after being subjected to the high temperature existing within the boilers.

This activity in the presence of heat is caused by the dissociation of this salt into magnesium hydrate and hydrochloric acid. The chemical reaction for this is as follows:

$$MgCl_2 + 2H_2O = Mg(OH)_2 + 2HCl$$

The acid attacks the iron and forms ferrous chloride with the liberation of hydrogen.

$$2HCl + Fe = Fe\,Cl_2 + H_2$$

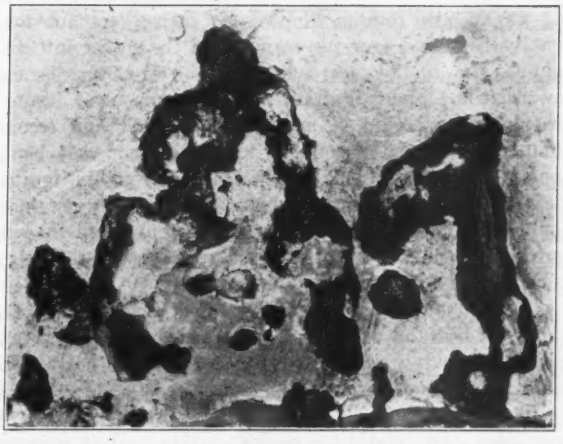
A corrosive cycle is then established by the reaction of the ferrous chloride with the original magnesium hydrate, with the producing of more magnesium chloride.

$$FeCl_2 + Mg(OH)_2 = MgCl_2 + Fe(OH)_2$$

Magnesium sulphate itself does not have the same corrosive effect as magnesium chloride, but can become exceedingly active in the presence of sodium chloride, due to the forming of magnesium chloride.

$$MgSO_4 + 2NaCL = MgCL_2 + Na_2SO_4$$

Waters which do not contain magnesium chloride may still be corrosive when containing magnesium sulphate and sodium chloride, due to the above reaction at the boiler temperatures.



FIGS. 1 AND 2. PHOTOGRAPHS OF A PLATE PLACED IN THE STEAM DRUM OF A BOILER BELOW THE WATER LEVEL. THE FEED WATER HAD A SMALL AMOUNT OF MAGNESIUM CHLORIDE PRESENT

In the following tabulation is an analysis of brackish water used for evaporator make-up in which a great deal of trouble was experienced with corrosion:

Silica	1.89 grains per gallon
Iron and alumina	1.46 grains per gallon
Calcium carbonate	6.40 grains per gallon
Calcium sulphate	.80 grains per gallon
Magnesium chloride	9.91 grains per gallon
Magnesium sulphate	13.05 grains per gallon
Sodium chloride	112.77 grains per gallon
Total solids	146.28 grains per gallon

This analysis illustrates the corrosion caused by all the magnesium salts so far discussed.

*With Cyrus Wm. Rice and Company, Pittsburgh, Pa.

As in the previous cases, the following reactions occurred: $MgCl_2 + 2H_2O = Mg(OH)_2 + 2HCl$

$FeCl_2 + Mg(OH)_2 = Fe(OH)_2 + MgCl_2$

The further production of magnesium chloride within the evaporators was brought about through interactions between magnesium sulphate, calcium carbonate and sodium chloride. This occurred as follows:

$MgCl_2 + CaCO_3 = CaCl_2 + MgCO_3$

$MgCO_3 + FeCl_2 = MgCl_2 + FeCO_3$

$MgSO_4 + 2NaCl = MgCl_2 + Na_2SO_4$

Calcium chloride is often found in boiler waters into which sea water finds its way, because of the reaction between magnesium chloride and calcium carbonate as shown in the foregoing analysis of brackish water. Although calcium chloride is not as effective in its action as magnesium chloride, it nevertheless does act as a corrosive agent.

Calcium nitrate and magnesium nitrate also act as corrosive agents when allowed to concentrate in the boiler water.

With nitrate of lime, the action takes place as follows:

$Ca(NO_3)_2 + H_2O = CaO + 2HNO_3$

$2HNO_3 + Fe = Ca(NO_3)_2 + H_2$

The lime (CaO) set free acts upon the nitrate of iron and forms calcium nitrate, as follows:

$CaO + Fe(NO_3)_2 = Ca(NO_3)_2 + FeO$

Waters containing calcium nitrate will give a pink color to phenolphthalein when becoming concentrated in the boiler. This is due to a small amount of lime set free, and is often misleading, as it is assumed that the water has a soda alkalinity sufficient to prevent corrosion.

Furnace Design for Traveling Grate Stokers---III**

FOR THE PROPER BURNING OF FINE ANTHRACITE AND COKE BREEZE, LENGTH AND SLOPE OF FRONT AND REAR ARCHES ARE IMPORTANT. BY H. S. COLBY*

BY far the greatest tonnage used for the production of steam in the anthracite market is found in No. 2 and 3 buckwheat. Until recently these fuels were burned in the single or front arch furnace, briefly described in the March 1 issue.

As the coal passed into the furnace it was ignited by the reflection of heat from the front arch, gradually burned out to an ash residue of varying carbon content and eventually passed over the rear end of the stoker into the ashpit. Due to the inert nature of the fuel, that is, the low volatile content, ignition was slow and only a limited amount of air could be applied to the first and second compartments or the zone in which the fuel was being ignited. After the fuel had become thoroughly ignited clear through to the grate surface, higher static pressures could be applied. The fixed carbon content could then be burned out in a reasonably short grate travel, that is, a travel over two or three compartments.

Difficulty with ignition necessitated the carrying of a thin fuel bed and as a result anthracite could not be applied to quickly fluctuating loads as there was not a sufficient mass of fuel burning in the furnace to respond quickly to changes in load. To meet the average condition of operation, particularly the central station load, it was necessary at all times to carry a relatively long fuel bed and to allow a condition of operation where, at low ratings, a considerable amount of partly burned fuel passed over the rear end of the stoker into the ashpit. This loss could have been avoided by operating with shorter fires during a light load period, but unless the increase in load could have been anticipated with reasonable certainty, this plan could not have been followed, as it was impossible with a short fire and a slow grate speed to increase the capacity rapidly by speeding up the grate. Whenever the grate speed was increased a condition soon developed where the green coal was carried back through the furnace without igniting. If slightly thicker fuel beds were carried and higher static pressures applied to overcome the increased fuel bed resistance, it aggravated a condition peculiar to the burning of anthracite coal, that is, fine particles of fuel were blown from the grate (sky-rocketing) and were burned in suspension. As the highest static pressures were carried at about the center of the stoker these burning particles of coal in suspension would fly up and then, falling back on the stoker over the last compartment they soon would drop into the ashpit before being completely burned, or else strike the bridge wall and drop through the space between the end of the stoker and the bridge wall into the ashpit. This sky-rocketing respresented an appreciable loss of carbon to the ashpit.

Developments in grate surface design finally permitted some increase in fuel bed thickness. The thicker fuel beds necessitated longer stokers, thus developing another difficulty which had not been so pronounced with shorter stokers. With the latter a smaller portion of the grate surface was exposed to the boiler heating surface and as a result the combustible in the ash residue on the rear end of the stoker could be kept above the ignition point for a longer period than when long stokers were used. These long stokers, due to the infiltration of air through the inert residue on the rear end of the stoker, increased the combustible loss to the ashpit and lowered the quality of burned gas obtainable. Recognition of this difficulty was responsible for the consideration of a rear arch in the burning of anthracite.

As first installed, in connection with stokers for burning anthracite, rear arches were quite short, their purpose primarily being that of shielding the extreme rear end of the fuel bed from the boiler heating surface and, by reflection of heat from the hot zone of the fuel bed, keeping the temperature of the residue above the ignition point. This short rear arch also reduced the loss due to sky-rocketing as the fine particles dropped back onto the fuel bed at a point which permitted a reasonable length of travel before passing into the ashpit.

Shortly after the rear arch was applied in the burning of anthracite it was discovered that combustion could be improved by modifying the customary air distribution and applying the highest static pressures just under the front end of the rear arch instead of under the rear end of the front arch. The high static pressure at this point caused the fine particles that were blown from the grate to be deflected downward, falling back on the fuel bed under the front arch. The stream of gas, rich in oxygen, coming out from under the rear arch, and meeting the stream of gas deficient in oxygen, coming from under the

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** Part I appeared in the March 1 issue and Part II in the March 15 issue, 1926.

front arch, resulted in an intimate mixing of these streams in the throat between the arches where the temperature was high enough to insure complete combustion with only a short travel beyond the point of mixing. The discovery revolutionized the design of furnace for the burning of anthracite and is directly responsible for the present trend of furnace design.

Highest Combustion Rate Is Under Rear Arch

It is now the accepted practice to burn anthracite by retarding the application of air on the forward and central zones and by carrying the highest static pressure on that section under the rear arch. The rear arch is set at a slight angle to the horizontal so that the air and fine coal striking this arch at high velocity are deflected forward horizontally with such velocity as to sweep across the throat or opening between the front and rear arches. Air is applied only in a sufficient amount to the forward and central zones to generate carbon monoxide, all of the air for completing combustion being supplied through the zone under the rear arch. The heavier particles of coal bank up under the rear arch to about double the normal thickness of the fuel bed. This method of operation, in which air to the forward zones is reduced, permits carrying much thicker fuel beds without experiencing difficulty

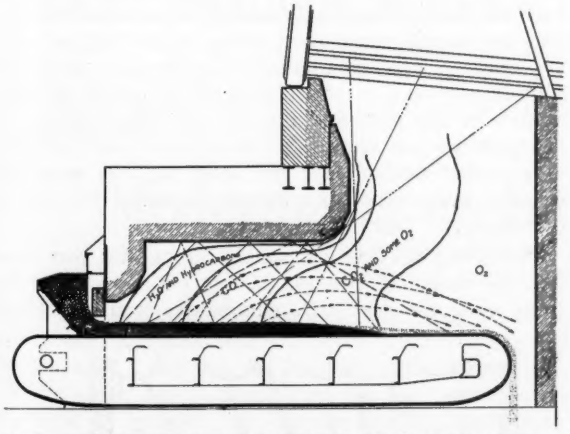


FIG. 1. THIS SHOWS WHAT HAPPENED WHEN FINE ANTHRACITE WAS BURNED WITHOUT A REAR ARCH

with drifting or sky-rocketing, as the pressures carried under the thick fuel bed at the front of the stoker are not sufficient to break through or agitate this fuel bed.

After mixing in the throat, the gases pass upward to the boiler heating surface, the height of the boiler setting determining the length of travel from the point of mixing to the boiler. This controls the quality of gas obtainable, so that with a high setting and long gas travel, it is possible to operate with little excess air. With a low setting and short gas travel, more excess air must be used to insure complete combustion before the gases enter the tube bank. This method of operation results in such agitation of the fuel bed and concentration of heat as to burn out the combustible in the ash to a minimum.

Although this method of operation results in a considerable quantity of coal being burned in suspension in the furnace, the loss due to fine coal being carried up into the boiler setting and breeching, is reduced. These fines are now projected at a high velocity in an opposite direction to that which they must travel to enter the boiler, and as a result, a smaller percentage of fine coal and ash is carried up in suspension with the gas into the boiler setting. Since this operation allows a thick fuel bed at all times, and in such a state of combustion as to permit an immediate increase in the rate of heat liberated, it gives ample assurance of meeting sharply fluctuating loads and extreme peaks.

The double arch furnace design not alone increased the efficiency and capacity obtainable with the burning of No. 2 and 3 buckwheat, but permitted the burning of No. 4 buckwheat and river coal, grades of fuel which were never

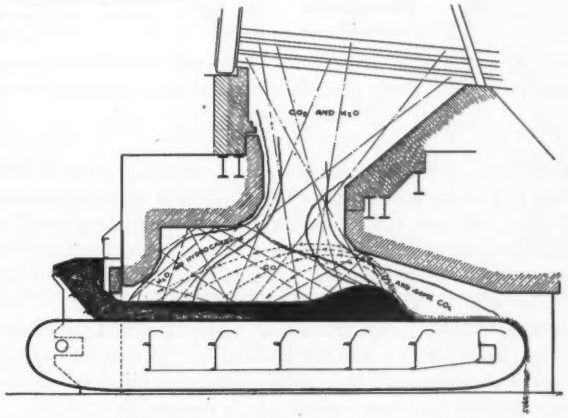


FIG. 2. IN ORDER TO REDUCE THE CARBON IN THE ASH AND ALSO OBTAIN GOOD MIXING OF GASES WITH FINE ANTHRACITE, THE ZONE OF INCANDESCENCE IS UNDER THE REAR ARCH INSTEAD OF AT THE FRONT

burned successfully in the single arch furnace. In Fig. 1 is shown the customary single arch furnace design with the light lines drawn from fuel bed to arches and the boiler heating surface indicating the heat propagated by radiation. The heavier and irregular lines indicate the streams of gas liberated from the fuel bed. It will be noticed that this design of furnace permits considerable infiltration of air through the rear end of the fuel bed without providing for the mixing of this air with the combustible gases generated under the front arch. The light broken lines and arrows indicate the sky-rocketing of fines from under the front arch onto the rear end of the fuel bed and into the ashpit. Figure 2 illustrates a modern double arch furnace under a boiler of the same setting height as shown in Fig. 1. It may be observed that the lean gas delivered through the rear zone is deflected at high velocity into the stream of gas generated under the front arch and throat. This illustration also clearly indicates the increased reserve of fuel in process of combustion.

In order to determine the effect of a rear arch when burning No. 2 buckwheat, tests were run on a traveling grate stoker under a 635-hp. boiler, horizontally baffled. At first, as shown in Fig. 3, the unit was equipped with a front arch only. Later, as shown in Fig. 4, a rear arch of the "sprung" type was installed. Data shown in the Table are representative of these tests and clearly indicate the marked increase in efficiency after the rear arch was installed.

Although coke breeze is a low volatile fuel, at first the steps in the development of the furnace design more closely paralleled that of the burning of bituminous coals.

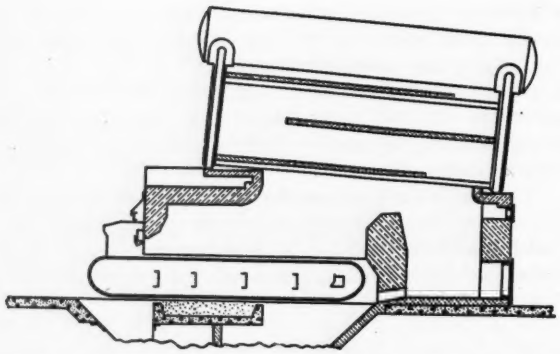


FIG. 3. HERE IS A "WIDE-OPEN" FURNACE WITHOUT A REAR ARCH, WHICH GAVE POOR RESULTS WHEN BURNING FINE ANTHRACITE

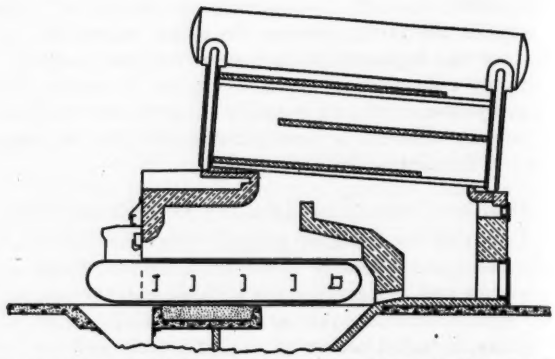


FIG. 4. AFTER PROVIDING A REAR ARCH, THE SAME FURNACE SHOWN IN FIG. 3 GAVE AN INCREASE OF OVER SIX POINTS IN EFFICIENCY

Formerly, it was customary to burn certain grades of this fuel in a single arch furnace having quite a long front arch, in fact, an arch closely following the proportions used in the burning of bituminous coal. Static pressures were increased gradually from the front of the stoker to about the center and then tapered off under the rear section of residue. Difficulty experienced in burning this fuel in the single arch furnace was the chilling of the rear end of the fuel bed exposed to the boiler heating surface before the combustible had been reduced to a reasonable amount.

This condition also was reflected in the quality of gas due to the air which passed through this residue and diluted the furnace gas. The ashpit loss was further increased by the sky-rocketing of fine particles from that section of the fuel bed under which the highest static pressures were used. These flying particles of burning fuel would fall back on the rear end of the fuel bed, and drop down through the space between the end of the stoker and the bridge wall. A large amount also was carried up into the boiler setting and breeching.

Coincident with the adoption of the rear arch for the burning of anthracite, the rear arch was applied for the burning of coke breeze. These arches were comparatively short and inclined at quite a sharp angle, following in general the outline shown in Fig. 5. This furnace design materially improved the quality of both the gas and ash. The extreme rear end of the fuel bed was shielded from the boiler heating surface and the angle of the rear arch was such that a considerable amount of heat was reflected from the central incandescent section of the fuel bed onto the residue. This maintained a temperature above the ignition point and permitted the burning out of the combustible in this section of the fuel bed. Sky-rocketing of fine particles was reduced as the higher static pressures were carried further back and these particles were now deflected toward the front instead of toward the rear of the setting.

Deflecting the lean gas passing through the rear zones into the stream of rich gas passing out from under the front arch, the rear arch eliminated stratification and

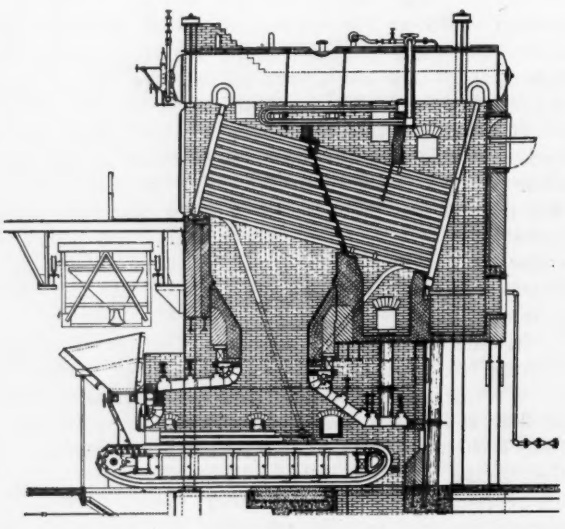


FIG. 5. THIS FURNACE DESIGN IS SATISFACTORY FOR BURNING COKE BREEZE AT LOW RATING BUT WITH A HEAVY LOAD THE SLOPE OF THE REAR ARCH CAUSES AN EXCESSIVE SLAGGING OF THE TUBES

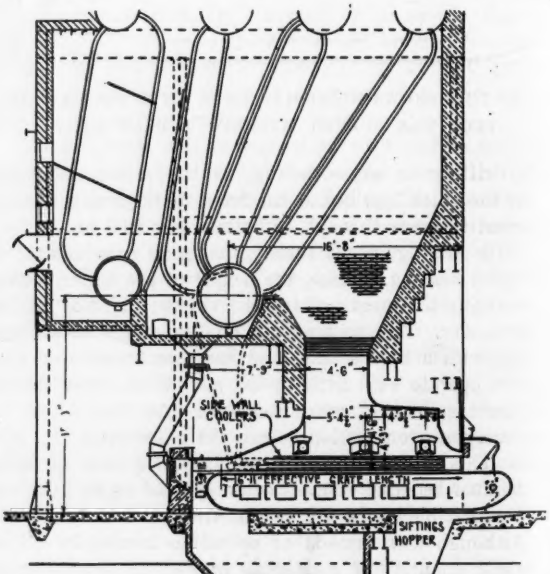


FIG. 6. THIS IS THE LATEST FURNACE DESIGN FOR BURNING COKE BREEZE. NOTE THE SIMILARITY TO THAT FOR ANTHRACITE (FIG. 2)

reduced the amount of excess air required for complete combustion. Some difficulty was experienced in the operation of furnaces of this design when the percentage of fines in the coke breeze exceeded 20 or 25 per cent. Quite often this percentage of fines, due either to the method of screening or handling, was much increased. If the usual air distribution was used difficulty was experienced from the extremely large amount of fine coke carried in suspension into the setting and with the slagging or ash deposition on the lower rows of tubes.

Difficulty in the burning of coke with a high percentage of fines has been overcome by adopting a furnace design which is substantially the same as that used for the burning of anthracite, as shown in Fig. 6. With this furnace, the high static pressures are carried under the rear arch and the operation closely parallels that obtained in the burning of fine sizes of anthracite. The adoption of this design for the burning of coke breeze has entirely eliminated all difficulty with slagging and the carrying of fine particles of coke into the boiler setting.

DUE TO THE REAR ARCH SHOWN IN FIG. 4 THE PRESENT OVERALL EFFICIENCY IS MORE THAN SIX POINTS HIGHER THAN WITH THE FURNACE SHOWN IN FIG. 3

Design of Furnace Shown in	Duration, hr.	Steam pressure, lb.	Degrees superheat	Feed water temperature	Flue gas temperature	CO_2, last pass, percent	Coal analysis (as fired) No. 2 buckwheat					Combustible in dry refuse, Percent	Boiler hp. per hr.	Percent rated capacity developed	Equivalent evaporation per lb. coal, as fired, lb.	Efficiency of boiler, furnace and grate, percent
							Fixed carbon	Volatile matter	Ash	Moisture	B.t.u. per lb.					
Fig. 3	12.0	174	68	53	574	12.5	69.00	6.60	17.08	7.32	11271	28.1	975	154	7.92	66.5
Fig. 4	12.0	173	54	75	556	14.1	70.30	6.10	17.05	6.55	11448	15.6	954	150	8.60	72.9

Modernizing an Industrial Power Plant

NEW EQUIPMENT INSTALLED WHILE PLANT WAS KEPT IN OPERATION SHOWS BIG SAVINGS

SOME TIME AGO the Bemis Brothers Bag Co. came to the conclusion that the power plant at their bag factory in St. Louis was fast becoming inadequate to supply the power requirements and was also inefficient as measured by present day standards. The engineering firm of Larkin and Co. of the same city was called into consultation and after their engineers had inspected the plant and submitted a report, were commissioned to make the necessary changes to modernize the plant, keeping the expense as low as possible.

At the time of the engineers' inspection, the boiler plant consisted of four 72-in. by 18-ft. horizontal return tubular boilers set over inclined grate stokers of the Roney type. Feed water was heated by a feed-water heater located in the engine room and pumped into the boilers by a motor-driven triplex pump. The boilers ranged in age from 12 to 20 yr. and at various times in the course of their life had been subjected to severe usage, particularly since the load had become enlarged. The stokers were in bad condition and the repairs necessary to restore them to good condition would have cost as much as entirely new equipment.

Electric power was generated by two direct current generators. In the engine room there was installed an old Fulton Corliss engine direct connected to a 150-kw. generator. There was also a second generator of 40-kw. capacity belted to the engine shaft by a chain belt. Both of these generators were of obsolete design and were loaded to the point where a fan was kept blowing on the commutator of the large machine to keep it from burning up. A tandem compound slide valve engine direct connected to a 100-kw. generator provided standby and additional service. The engine was in bad condition due partly to its age and partly to the fact that it had often been overloaded. Compared to modern equipment, it was an extremely inefficient machine.

A switchboard composed of several marble panels equipped with old model instruments of doubtful accuracy, completed the array of equipment in the engine room. The circuits were controlled by knife switches and open link fuses installed on the face of the board. The generators were protected by single-pole circuit breakers which were wedged in a closed position so that they would not open on the loads which they were normally called upon to carry.

The engines exhausted into a header which connected into the heating system and to apparatus in the factory where it was used for process purposes. A back pressure valve installed in the atmospheric exhaust line maintained a pressure of 1½ lb.

When the engineers were first called in to inspect the plant, observations indicated that only 5 to 6 per cent CO_2 were being obtained and that the stack temperatures were running from 600 to 650 deg. F. There were no meters nor any other means of obtaining the boiler performance, but it is doubtful whether 6 lb. of steam per pound

of coal was being obtained. The coal used was the best grade of washed screenings available in the district, costing at that time $6.00 per T.

Water-Tube Boilers Replace Horizontal Return Tubulars

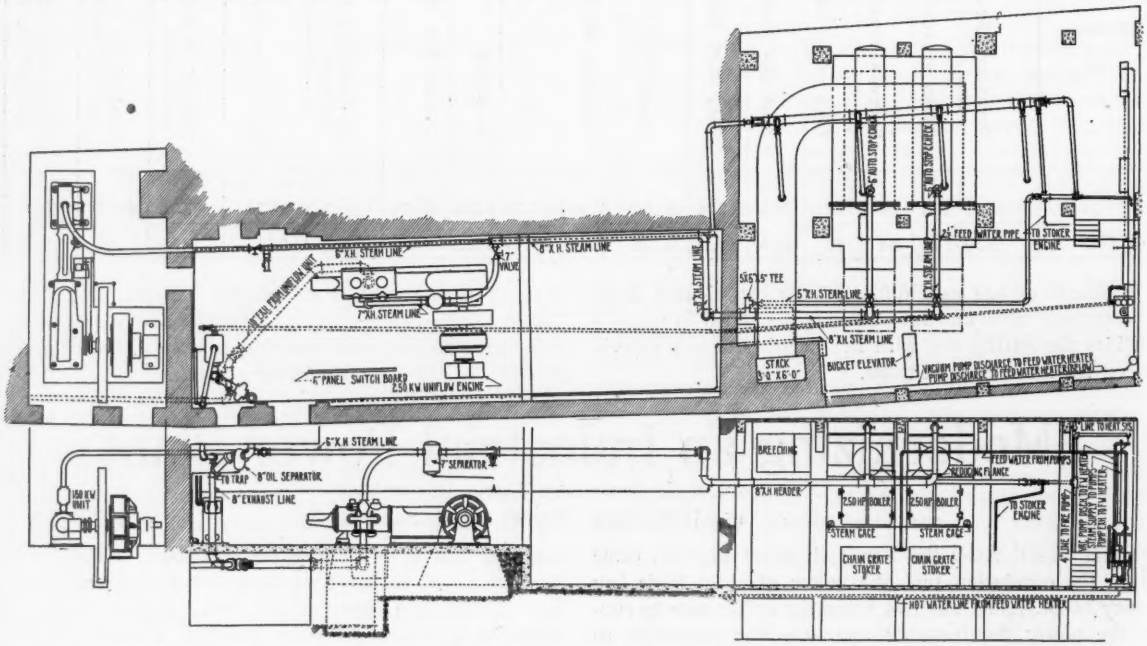
After careful consideration of the situation, it was decided to remove the fire-tube boilers together with the stokers and replace them with two 2500-sq. ft. water-tube boilers set over chain grate stokers which could burn the cheaper grades of fuel available in this district. For the generation of power, it was decided to remove the 100-kw. tandem compound set and replace it with a modern uniflow engine, leaving the Corliss unit in place for standby service. A new switchboard with ample and modern switching mechanisms and modern instruments was to replace the old one. This plant operates 10 hr. a day 5½ days a week and the work of remodeling had to be carried on without interrupting the operation of the mill, due to the rush of business.

The construction of the building was such that in designing the new plant only little additional space was available in the engine room and none in the boiler room. The latter was located in a concrete building and had a double line of concrete columns which did not line up with each other or with the building walls. The old boilers were set in a single battery with a column between each two boilers. It was necessary therefore to install the new boilers in the same space as was occupied by the old units. The head room also was limited. The two center boilers being in the poorest condition, it was decided to remove them first and carry the plant load during the period of construction with the two outside ones.

Two new water-tube boilers, each with 2500 sq. ft. of heating surface and fitted with chain grate stokers were ordered. Owing to the cramped condition these boilers had to be specially designed so that they would fit in the space available, and would be as shallow as possible so as to provide adequate combustion space. In order that construction work could proceed it was necessary to construct a temporary header that would not only allow the plant to be kept in operation but would permit the connection of the new boilers to the system with a minimum of lost time to the factory.

The new boilers were erected, bricked up, and dried out by providing a temporary flue made of 12-in. stove pipe. At first a light wood and coal fire was kept burning during the day but it was soon found that the loss of draft at the other boilers due to this method of operation was so great that it was necessary to run the drying fires only at night.

A new stack was erected. This was built as an integral part of the adjacent brick building, having an area of about 12 sq. ft. and being 110 ft. in height. In order that sufficient draft would be available to insure operation of the new natural draft chain grate stokers, a 40-ft. steel stack was erected on top of the brick stack.



PLAN AND ELEVATION OF POWER PLANT AT THE BEMIS BROTHERS BAG CO.

By careful planning and laying out a schedule for each of the workmen and by making certain that all material was on the job and was of the proper dimension, the plant was shut down on a Thursday night and between that time and Monday morning, the new steam header and breeching was erected and placed in service. This work was followed by the dismantling of the remaining boilers. A new floor was then laid where they had stood. Finally the boiler room instruments such as draft gages, flow meters, and CO_2 recorders were added and placed in service.

In the engine room a 350-hp. uniflow engine was installed and a new switchboard erected. A temporary feeder was run connecting the new board with the old and by careful work the circuits were transferred to the new board without a single interruption.

It is apparent that these changes were expensive on account of the care necessary to prevent interruptions to the plant, but subsequent operation of the new equipment fully justified this expense. It is of interest to know that

the new engine paid for itself in one year because of its greater economy as compared with the old unit.

In concluding this article we wish to acknowledge our indebtedness to J. N. Junkins, of the Larkin Engineering Co. of St. Louis, for assistance in supplying the data used in its preparation.

Turbine Drive for Feed Pumps Saves Cost Quickly

NEW UNIT, INSTALLED IN INTERURBAN RAILWAY POWER PLANT, PAYS FOR ITSELF IN LESS THAN 4 YEARS. BY DANIEL REIDEL.*

BY REPLACING TWO duplex pumps used with its boiler feed water pumps with a turbine-driven boiler feed pump, the Toledo, Bowling Green and Southern Traction Co. of Findlay, Ohio, has earned a return on its investment of 28.9 per cent, the new pump thus paying for itself in less than four years. The power plant of the company, which supplies electric current for operating the interurban cars of the company and which also supplies light and power to several towns, has an average load between 4200 and 4500 kw., with a night load as low as 1400 kw. Steam is generated by six 250-hp. Babcock & Wilcox

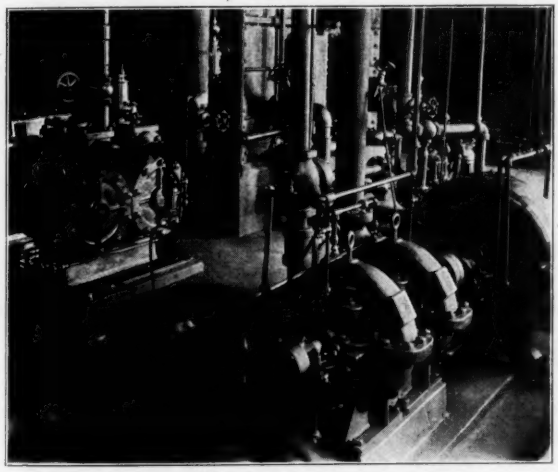


FIG. 1. TURBINE-DRIVEN CENTRIFUGAL PUMP REPLACED TWO DUPLEX PUMPS, ONE OF WHICH IS SHOWN

boilers, two 500-hp. Stirling boilers, and two 600-hp. Stirling boilers, all equipped with Jones underfeed stokers. There is usually an aggregate of 1200 hp. of boilers not in operation, so that the boilers are kept in good operating condition.

Two 14 by 7 by 12 duplex pumps, now held as standbys, were used until December, 1924, as the boiler feed water pumps, operated at full volume to supply the required volume of feed water during the average day conditions. When it became necessary to install a new boiler feed pump, a Worthington volute centrifugal, style SD, direct-driven by a General Electric 60-hp., 2000-r.p.m., style D-51, two-stage turbine was selected. The boiler feed water is pumped at 225 lb. pressure with a four-stage pump. The turbine is equipped with a pump governor, with steam pressure on one side and boiler feed on the other. Accurate control of the turbine is provided by this governor.

Although occupying only one-fourth the floor space, this pumping unit has 50 per cent greater capacity than both the previous pumps combined. The water rate of the turbine is approximately 30 lb. per hp. at three-fourths load, 20 per cent less than the water rates of the two duplex pumps. This is not a factor, however, since exhaust steam is used for heating the feed water.

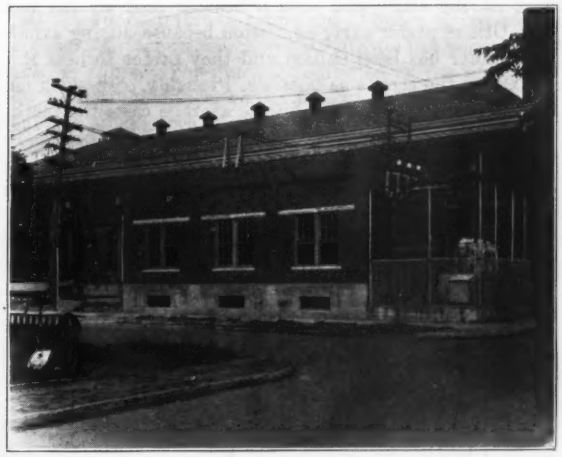


FIG. 2. POWER HOUSE OF TOLEDO, BOWLING GREEN & SOUTHERN TRACTION CO.

Repairs on the duplex pump units averaged $235 a year; to date there have been no repairs on the turbine-driven unit. The oiler spends about 15 min. a day at the turbine-driven pumps, mostly for wiping; the duplex pumps required 1¼ hr. daily because of the need of constant attention to lubrication. The turbine requires about ½ gal. of oil per month, whereas the other pumps required a gallon of oil per day. The new unit has been so noiseless and vibrationless that red stripes have been painted on the coupling. This was done to prevent accidents, which might have occurred if someone had come in contact with the coupling, thinking the turbine was not running.

Comparison of operating costs has shown that the saving in operating cost by using the turbine unit is $641.75 per yr., which pays for the unit in less than 4 yr. The present day prices of both turbine and duplex pumps are used in the figures. In addition there is a saving in floor space of $22 a year, and this floor space will soon be worth much more, since the power plant is becoming more crowded. The total annual saving is $663.75, a return of 28.9 per cent on the investment.

RECOGNITION of the importance of power is being accorded in unexpected quarters. At a recent conference, called at Worcester, Mass., by the governors of the six New England states, and attended by representatives from more than 200 business and agricultural organizations, half of the 2-day program was devoted to power.

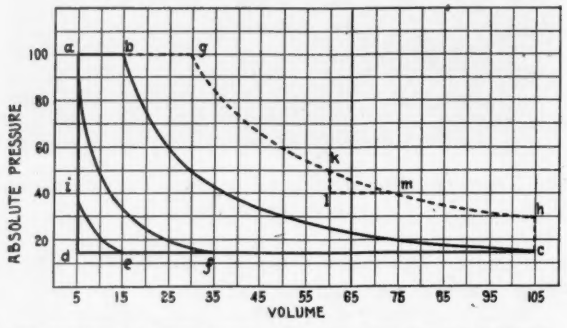
IT PAYS to use the best grade of materials and chemicals in a water softening system.

*Superintendent of Motive Power, Toledo, Bowling Green and Southern Traction Co., Findlay, Ohio.

Improvement of Engine Performance

Study of Diagrams to Indicate Proper Compression and Receiver Pressure. By R. H. Morris

MANY engineers, when setting engine valves, prefer late admission because of the fact that in the early part of the stroke the force of the steam, exerted directly against the pins and bearings, has but a small turning effect on the shaft and puts a heavier lead on the bearings. Others prefer early admission because during exhaust the cylinder has been chilled and they prefer to heat it up as early in the stroke as possible. Probably both sides have their advantages, although in the average case, the method of having admission occur just early enough to give full pressure at the beginning of the stroke, is preferable. Admission earlier than this cuts down the area of the card and if later, results in wiredrawing. If the steam valve is opening while the piston is nearly stationary, the only steam flowing through is that required by the clearance



THEORETICAL INDICATOR DIAGRAM FOR STEAM ENGINE

volume, and by the time the piston has traveled far enough to require steam, the valve is fully opened reducing wiredrawing to a minimum.

Wire Drawing and Throttling

In connection with the subject of wiredrawing and throttling, one often hears the argument that no heat is lost in the process and theoretically it should make no difference. That this argument is not sound can easily be shown. In the Carnot cycle, which is approximated in an engine with high compression, the efficiency is $\frac{T_1 - T_2}{T_1}$.

If steam is throttled, the pressure drops, the superheat or quality increases but the final temperature is less than the initial and the Carnot cycle efficiency is lower because T_1 is lower. A simpler illustration is by the use of the Mollier diagram which may be found in any standard text book on steam engineering. Assuming steam at 160 lb. and 100 deg. superheat, we find from the Mollier chart that this steam has 1252 B.t.u. per lb. When expanded adiabatically down to 2.5-lb. pressure as in an ideal engine the exhaust steam has a quality of about 80 per cent and a heat content of 958 B.t.u. per lb. The same steam throttled to 120 lb. would have a superheat of about 118 deg. and if expanded in an ideal engine to 2.5 lb. back pressure would exhaust the steam at a quality of about 86 per cent with 975 B.t.u. per lb., a loss of 17 B.t.u. from throttling although no heat was lost in the process. An efficient engine would convert about 70 per cent of this heat drop into work. A possible exception to this loss by throttling is when dry saturated steam is used. In this case, superheating occurs and it is possible that the gain in cylinder efficiency due to the superheat offsets the loss from throttling. This point, however, is open to debate.

Proper Compression

Determination of the proper compression is a more complicated matter. Theory cannot be relied upon in this case. Clearance decreases the efficiency of an engine but it can be proved thermodynamically that if compression is carried up to the initial cycle pressure the loss from this source is eliminated. As all practical engines must have clearance we might assume from the above that one should carry the maximum compression at all times for maximum efficiency. The accompanying diagram has been drawn for an engine with 5 per cent clearance using steam at 100 lb. and exhausting at 14.3 lb. (1.3 lb. gage at 3500 ft. elevation). This corresponds to 10 per cent cutoff, all cylinder losses have been neglected and the expansion curve drawn according to the equation,

pressure $\times$ volume = a constant.

If the cylinder is of such a size that 10 per cent of the stroke requires 1 lb. of steam, the cylinder at point b contains 1.5 lb. One-half pound is taken up by the clearance volume and 1 lb. by the piston displacement. With no compression, the card abcd with an area of 3 sq. in. would be obtained. The total volume of the cylinder at the extreme piston travel is 105 per cent of the displacement. At the beginning of the stroke it is 5 per cent so that the steam trapped in the clearance space is $\frac{5}{105} \times 1.5$ or 0.07 lb. and 1.43 lb. of new steam must be supplied each stroke. This gives an area of $\frac{3.00}{1.43}$ or 2.1 sq. in. per lb. of steam.

If, however, compression occurred at f, the clearance volume would be full of steam at boiler pressure when admission occurred and only 1 lb. of new steam would be required at 10 per cent clearance. The area of abcf is 2.4 sq. in. The power output of the engine has been decreased to 80 per cent but the thermal efficiency is about 14 per cent higher.

Published tests show that this reasoning does not apply practically to Corliss engines. If we start with no compression, as abcd, and gradually increase compression, an increase in efficiency results up to the point of about two times the clearance. From that point on, increasing the compression causes a decrease in efficiency. Proper compression based on this data is shown by the short line ei. At 25 per cent cutoff, as at g, the final compression pressure will be but a few pounds above the pressure at release, resulting in a small cushioning effect, so that ei is close to the minimum compression possible. Some engines will require more, some less, for quiet operation and as most engines are fairly well loaded the minimum clearance possible is undoubtedly the best single rule to follow as it gives the maximum power output with the maximum, or close to the maximum, efficiency.

Determining Proper Receiver Pressures

Receiver pressures are likely to be too low rather than too high. Either will cause a loss, the first by increasing the loss due to incomplete expansion in the high pressure cylinder, the second by causing a loop of negative work on the same cylinder. With an engine already in service, a fixed cylinder ratio and a definite load to carry the usual condition calls for a receiver pressure such that an even distribution of the load between the two cylinders is obtained. This is more important in a cross compound than in a tandem engine as an unequal division in the former will cause vibrations and overloading of the bearing surfaces on one side.

Low pressure cutoff has no effect on the total output of the engine nor on the final exhaust pressure. This is controlled from the high pressure side and the expansion line will continue as though the steam were expanded in a single cylinder. For this reason the receiver pressure does not receive the attention that it should.

For low steam pressures it is possible to build an engine to give complete expansion in the high pressure cylinder, i.e., no pressure drop from release to receiver pressure. For higher steam pressures the cost of the engine would be excessive and it is usual to sacrifice the toe of the high pressure card (the area klm). This was advocated by Rockwood as early as 1890. It is equivalent to leaving the intermediate cylinder out of a triple expansion engine.

If the low pressure cutoff is varied with the high pressure cutoff, the receiver pressure and consequently the ratio of the load on the two cylinders, will remain practically constant. With fixed low pressure cutoff an increase in load will raise the receiver pressure throwing more load on the low pressure side. The same effect will be given by shortening the low pressure cutoff at constant load.

Correct receiver pressure may be calculated or arrived at graphically, although the actual expansion in the engine will vary considerably from the theoretical and, if possible, it is best to combine the indicator cards and determine the correct receiver pressure by means of a planimeter.

Determination of the actual expansion line for purposes of analysis is best done by transferring the indicator card to logarithmic cross section paper. The expansion curves then appear as straight lines and leakage of the valves or piston will show up as slight curves at the two end sections of the expansion line. As a rule, the middle third of the line is unaffected by leakage and can be used for a determination of the true slope of the line.

Although the indicator is not accurate enough for many purposes, its use is necessary and of inestimable value to the engineer. To those engineers who are not familiar with logarithmic cross section paper, a study of the paper, "A New Analysis of Cylinder Performance of Reciprocating Engines," by J. P. Clayton, in the 1912 volume of the A.S.M.E. Transactions will be of great interest.

A new angle in the controversy in Massachusetts for diverting the Ware and Swift Rivers in Massachusetts as sources of a water supply for Eastern and Central Massachusetts, has been given by the state of Connecticut, which has under consideration a complete survey of these branches of the Connecticut River. Connecticut fears such diversion may result in reduced water power for some of its industries located along that river.

Corrosion and Protection of Condenser Tubes*

Causes and Treatment of Several Types of Condenser Tube Corrosion Are Discussed. By C. D. Bengough and R. May

CONSIDERABLE ADVANCES have recently been made in the knowledge of corrosion phenomena, and it has become desirable to rearrange in order of importance a number of factors which contribute to the corrosion of condenser tubes. The gradual falling off in the number of cases of dezincification continues, while the relative frequency of other types of corrosion appears to be increasing at about the same rate. This change appears to be following the more general use of condensers of higher technical efficiency and is probably due largely to the lower temperature and higher water-speeds in such conditions.

SUMMARY OF METHODS OF PREVENTING CORROSION

Type of Corrosion	Causes and Accelerating Factors	Methods of Retarding Attack	Suggested Methods of Protection
Dezincification	Composition of tube. High temperature. Deposits of mud and slime. Tin coatings.	Use tubes low in iron. Increase water-speed. Avoid deposits by all means available. Use untinned tubes.	Use tubes containing about 0.02% arsenic.
Pitting and Deposit attack	Local changes in scale. Injury to scale in cleaning. Composition of water. Adhesion of deposits. High temperature in certain cases.	Avoid deposits by all means available. Avoid drastic methods of cleaning. Avoid contamination of water by sewage or other organic matter, or by gases such as CO_2 and H_2S.	Use a protection process, which deposits a scale of iron compounds. In some cases it is possible that a coating of bituminstic solution or of boiled linseed oil may be of use.
Impingement attack	Presence of air-bubbles in the water. High water-speed. Excessive turbulence. Vortices in water-box causing non-uniform distribution of bubbles.	Avoid presence of free air by all possible means. Improve the smoothness of flow.	Form a resistant scale on the new tubes by the method described on p. 26 of this pamphlet, or try tinned tubes, or tubes coated with bituminstic solution.

The Mechanism of Corrosion

When a portion of 70 : 30 brass, such as a condenser tube, is immersed in clean sea-water, a rapid action starts. A film of insoluble corrosion products soon forms over the metal surface; this film hinders the diffusion of the corroding media to the metal and the action slows down. This protective action may or may not be effective, so that it is of interest to consider what may happen to an initially protective film to modify its effect. The presence of such a film accounts for the different behavior of new and old tubes frequently observed in a condenser.

Types of Corrosive Action in Condensers

Following is a list of various types of action commonly observed in condenser tubes: slow general action under a protective scale; slow layer dezincing under a protective scale; pitting (round type); plug dezincing; deposit attack, due to loose corrosion products and foreign substances; impingement attack by fluids, due to erosion of

*Abstract of a paper entitled Notes on the Corrosion and Protection of Condenser Tubes, prepared for the Corrosion Research Committee of the Institute of Metals, London, England.

scale; true erosion of metal produced by abrasives such as sand; pitting (tailed type); scale kept thin by chemical action, resulting in general corrosion and in isolated pits; absence of scale owing to presence of acids, etc., resulting in general thinning.

Tube Failures Attributed to Tube Itself and to External Conditions

Originating causes which have been suggested as resulting in failure of tubes are as follows:

(1) Causes due to the tubes: laminations, spills, pores; unsuitable composition; unsuitable crystalline structure; mechanical failure, e.g., collapse under packing, splitting, season-cracking.

(2) Causes due to external conditions: impingement of aerated water-streams; local changes in the original protective scales; presence of certain injurious foreign substances in the cooling water; mechanical injury to a protective scale; too high a temperature under certain conditions; movement of tubes; unsuitable packing; ferrule troubles; stray currents from electrical machinery; erosion on the outside of tubes; chance effects.

Except in rare cases corrosion takes place on the inner (i.e. the water) side of the tubes, and in practice it usually happens that many of the factors listed above are not under direct control of the engineers in charge. Frequently the cause of failure is not a single item in this list, but two, three, or more working together.

The following is a statement of the possible methods of lessening the corrosion of 70 : 30 or 70 : 29 : 1 tubes.

1. Water treatment: Physical, e.g. filtration (impracticable on a large scale), removal or uniform dissemination of air-bubbles; chemical, e.g. softening, neutralization, Cl treatment, von Wurstemberger's process; electrolytic, e.g. Harris-Anderson, Cumberland and Gush systems.

Method of Preventing Corrosion

The accompanying table summarizes the methods by which main types of corrosion may be retarded, and in certain cases prevented. It is based on all the data at present available, but may need modification when further results are obtained. The actual measures taken at any plant will, of course, be governed by local conditions. The table is intended as a rough guide.

Overloading Causes Diesel Engine Failures

Reliability Is Influenced by Design, Method of Rating, Grade of Fuel, Altitude, and Average Air Temperature. By J. J. McDougall.

SO MANY variable factors enter into the operation of the Diesel engine that the dimensions of the cylinder and speed of an engine mean little unless the details of construction and the conditions for which the engine was designed, are known, such as fuel oil, altitude above sea-level and average air temperature. The operator can not figure on any over-load except for momentary purposes such as would be the case with an engine-driven generating set when a large motor is started up. All the load he can depend on getting continuously is its rated load and this only when the engine is in good running order. Leaky valves will soon burn out, a leaky piston packing, if bad, will cause the piston to seize and if full load must be carried repairs of such defects must be made at once for they can be put off only by reducing the load. If allowed to get in bad shape, the engine may cease operation entirely.

In present practice, the rating of a Diesel engine generally is near the maximum load possible, this rating being based on a certain set of conditions. The maximum possible rating or load which a Diesel engine will develop depends to some extent on the weight of air in the combustion chamber of the cylinder after the piston has completed its compression stroke, or in other words, the clearance volume of the cylinder. This weight of air will burn only so much fuel-oil and no more; the injection of any more fuel will foul the cylinder, cause imperfect combustion and result in the engine dropping its load. If anything increases the weight of air in the cylinder then the rating can be increased and if anything reduces the weight of air, such as a leak, the rating is reduced and the safe or rated load is affected in the same manner.

If an engine is given a certain power rating at sea-level and then is moved to an altitude several thousand feet above, a deduction in rating of over three per cent per thousand feet increase in altitude must be made, due to the fact that the weight of a given volume of atmospheric air decreases in this ratio as the altitude is increased. For instance, at sea-level 1 lb. of air, at 60 deg. F., occupies 13.09 cu. ft.; at an altitude higher than sea-level the normal atmospheric pressure drops and the volume of 1 lb. of air increases in proportion, provided the temperature is the same, hence knowing the atmospheric pressure it is an easy matter to figure how much to reduce the rating. For instance, at 6000 ft. the atmospheric pressure is about 11.7 lb., hence 1 lb. of air will occupy $13.09 \times \frac{14.7}{11.7}$ or about 16.5 cu. ft. Since this is an increase of 20 per cent and as the volume of the engine cylinder remains the same, the weight of air necessarily must be decreased 20 per cent and the rating also.

Climate also can affect the rating. For instance, if the engine is rated at an inlet air temperature of 60 deg. F., then for every 5 deg. increase or decrease, a change of 1 per cent in the rating should be allowed. If the temperature is higher, the rating must be reduced and if lower, the rating can safely be increased. This fact has led some manufacturers to make statements that their engines were not affected by the altitude to any great extent. Such a statement is extremely misleading though it could be and has been demonstrated as a fact. For example, an engine rated at 100 hp. at sea-level, with the air pressure 14.7 lb. absolute and the temperature 60 deg. F. or 520 deg. absolute, was moved to an altitude of 3500 ft. where the atmospheric pressure was 12.8 lb. absolute and the temperature of the intake air only 0 deg. F. or 460 absolute. The actual rating under these conditions was

$$100 \times \frac{12.8}{14.7} \times \frac{520}{460} \text{ or } 98.5 \text{ hp.}$$

In this case the cold air counteracted the effect of the altitude but credit was given to a new set of adjustments

made on the engine. The owner, of course, has discovered that he has an over-rated machine as the temperature does not remain at zero but in hot weather goes up to 100 deg. F. or 560 deg. absolute. The rating then is

$$100 \times \frac{12.8}{14.7} \times \frac{520}{560} \text{ or } 81 \text{ hp.}$$

All this is based on the law of gases that $PV = RT$ where P is the absolute pressure in pounds per square foot; V, the volume of one pound of gas in cubic feet at that pressure; R, a constant for the gas, in this case air, and is 53.3; and T is the absolute temperature.

All claims, that the effects of the altitude can be overcome by adjusting the engine, should be well investigated for they are not always reasonable. If this were true the same adjustment should work at sea-level and increase the rating there. About the only practical way demonstrated thus far is to install an air pump and pump more air into the cylinders. This, however, does not always give results expected.

Quality of the fuel oil used also can affect the rating of the engine which may be designed for a fast burning oil and may not be capable of using a slow burning oil properly. This can usually be overcome by readjusting the fuel valve although at times it may cause the rating to be reduced 10 per cent or more. This is better understood as affecting the safe rating, or rated load of the engine.

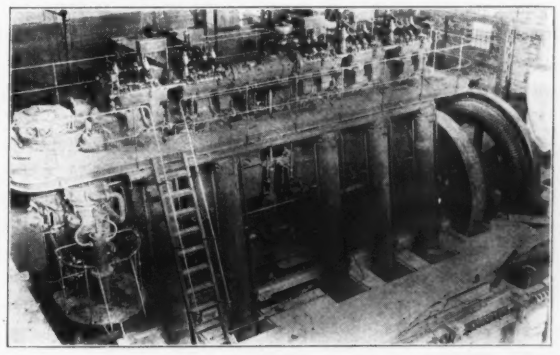
When fuel is burned in the cylinder, the air heats up and the pressure may change, the volume remaining constant, or the pressure remain constant and the volume change, or both volume and pressure may change, depending on how the fuel is burned. In the Diesel engine the fuel is supposed to be injected in such a manner that it maintains the pressure constant up to the point of cutoff, or where the fuel valve closes.

From the law $PV = RT$ it may be seen that as the volume increases at constant pressure, the temperature must be increasing and the more the volume is increased the greater must be the temperature. Temperature is the limiting factor for safe loads since at the end of the compression stroke it is 1000 deg. F., at the finish of combustion of fuel 3000 deg. F., and at the point of exhaust or release 1000 deg. F. A great many engines can not stand these temperatures, due to the fact that the metals used will not stand up under high pressure stress combined with high temperature.

When a Diesel engine is forced beyond its rated load the damage resulting always is caused by over-heating of some part as the pressures do not change to any great extent. Some engines appear to pull considerable over-load easily but if this load is maintained for such a length of time that valves start burning out, heads and liners crack, and pistons seize, the person responsible for the over-load is to blame for the break-down of the engine. It also should be noted that because a Diesel engine has several cylinders does not make it any more reliable as far as pulling full load is concerned, because each cylinder is an individual engine and must be considered so. If one cylinder gets in bad order or bad mechanical condition and fails to pull its share of the load and attempts are made to make the others do it, they will be over-loaded. On reduced loads it is claimed that if something should happen to a cylinder, causing it to cease work altogether, it can be left running idle until the engine can be shut down conveniently. This is not always true, as the failure of some cylinder will often throw the engine so badly out of balance and cause it to vibrate so badly that a wreck will result if the engine is not shut down quickly.

In Fig. 1 is shown a typical two-cycle Diesel engine rated at 1250 br. hp. at sea-level with inlet air at 60 deg. F. From various tests it was found that the friction load of this engine was 450 hp. Each cylinder develops 340 hp. or a total of 1700 hp. for all of the five cylinders. While such an engine generally is considered as one unit, it is really made up of seven separate units and the slightest failure of any one makes the pulling of full load impossible. When for any reason one cylinder fails and has to run idle, the possible load will drop by not only 250 hp. but 340 hp. and perhaps throw the engine badly out of balance.

Starting from the flywheel, there are first five power engines, then the low pressure air pump which has a displacement of about 140 per cent of the five power cylinders, delivering air at about 5 lb. pressure. The cross head of this pump drives the high pressure air pump for



THIS TWO-CYCLE DIESEL ENGINE IS RATED AT 1250 BR. HP. AT SEA LEVEL WITH INLET AIR AT 60 DEG. F.

fuel injection. This pump is driven with rocking levers and delivers air at about 1200 lb. pressure. All this machinery is reliable only when made of the proper materials and properly maintained, otherwise it is extremely dangerous.

When investigating the performance of any Diesel engine, the actual running time on full load should be determined, as an engine might be giving entire satisfaction in some plant where it was running on reduced load and might not be capable of pulling its rated load at all. To know an engine has been running several years without much trouble, means little, for a year in that plant might be considered as an industrial year of 300 days of 8 hr. each, or, a total of 2400 hr., whereas the new buyer would want the engine in a plant where a year was 365 days of 24 hr. each, or, a total of 8760 hr. and the engine might be entirely unsuitable in such a plant where periodic instead of daily overhauling was the rule.

In the accompanying table is shown a repair man's report on two Diesel engines which were credited with a year's successful run without undue troubles and will show how things are not always as stated. Full rating was never developed, that is, the guaranteed full rating, and it will be noted that the engines did not run the first few months of the year. All of the heads on one engine cracked after three weeks' run and one of the new heads, replacing these, broke in five days. On splitting this head

apart with wedges, an inch and a half of core sand was found in the water jacket and also it was discovered that the iron had not been properly heat treated for the work it had to do.

Compressor valves were continually breaking and dropping inside the cylinders due to poor design; a complete set of piston heads was lost due to a fault in the cooling arrangement and all the babbit on all the crosshead shoes on two engines came loose due to improper anchoring. The operating crew have no control over such matters.

In other plants conditions will be found just the opposite—the engines appear to be deliberately wrecked and

REPORT MADE BY A REPAIR MAN ON TWO DIESEL ENGINES

DIESEL ENGINE NO. 1

MONTH	HOURS RUN	NO. OF TIMES FORCED DOWN	HRS. WORK ON ENGINE	HRS. UNFIT FOR SERVICE	HRS. NOT REQUIRED	TOTAL HOURS
MARCH	720.75	10	21.75		1.50	744
APRIL	529.25	2	66.00		124.75	720
MAY	553.50	2	62.25		127.25	744
JUNE	552.75	9	86.75	34.50	46.00	720
JULY	324.50	3	139.00	265.00	15.50	744
AUG.	355.75		133.25	255.00		744
SEPT.	598.00	2	26.25	3.00	92.75	720
OCT.	701.75	1	11.00		31.25	744
NOV.	636.00	3	46.75	18.00	19.25	720
DEC.	678.75	1	19.75		45.50	744
TOTAL	5651.00	32	613.75	575.50	503.75	7344

DIESEL ENGINE NO. 2

MAY	556.75		42.25		145.00	744
JUNE	352.50	2	24.50		343.00	720
JULY	425.50	1			318.50	744
AUG.	397.50		81.50	80.00	185.00	744
SEPT.	424.50				295.50	720
OCT.	725.00	4	19.00			744
NOV.	686.00		16.00		18.00	720
DEC.	703.00	2	24.75	14.50	1.75	744
TOTAL	4270.75	9	208.00	94.50	1306.75	5880

	ENGINE NO. 1	ENGINE NO. 2
Per cent hours run	76.95	72.63
" " " working on engine	8.36	3.54
" " " engine unfit for service	7.84	1.61
" " " engine not required	6.85	22.22
TOTAL	100.00	100.00

only close investigation will show what is at fault. For an example, in a plant containing two Diesels the records show 187 shut-downs for the first year and 135 shut-downs for the second year. This would indicate that the engines were unreliable but investigation showed that the vast majority of the break-downs were caused by improper adjustments and poor maintenance methods, such as having 80 burned out valves in one year. Another plant, under the same conditions but using different maintenance methods, did not lose a single valve. As shown in the table, "The hours run" is the actual running time of the engines, "Number of times forced down" means the times the engines either quit of their own accord or were shut down suddenly to prevent a wreck. In either case no time was available to put a stand-by steam or gas plant into operation. "Hours work on the engine" is the time it actually took to do the repair work. "Hours unfit for service" is the time required to get new materials or make them; the last two items added together give the time the engine was unable to run. "Hours not required" means the stand-by plant was capable of handling all the load and it was not worth while to start the Diesel engine although it was ready to start.

The company owning the engines was satisfied with the saving made in fuel but nothing was said about reliability. In another plant where the engines never ran on more than half rating for 18 mo. the engines were considered an entire success but when called on suddenly could not develop full load and never will because the engines are over-rated. They are quite reliable, however, when run on their corrected rating—a reduction of 18 per cent for the altitude.

Reports showing Diesel engines running over 8000 hr. a year and averaging close to full load indicate that they must be doing good work and are fairly reliable.

Safety Posters Prevent Accidents

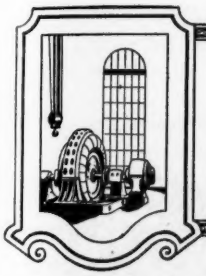
"ACCIDENTS ARE HUMAN MISTAKES," says W. H. Cameron, managing director of the National Safety Council. "Men don't always think; they lack imagination; frequently they forget; their judgment isn't uniformly sound; often they simply don't know and sometimes they take unnecessary and dangerous chances. Constructive safety posters make men more thoughtful, they arouse imagination, they remind men always to be careful, they teach from the experience of others and thus enable men to exercise better judgment, they show how to do things in the safe way and they warn men of the tragic folly of chance-taking."

Several posters that should interest people in the power plant industry are contained in the 1926 catalog of the N. S. C. Copies of the catalog and the large size posters may be had by addressing managing director Cameron at 108 East Ohio St., Chicago, Ill.

Power, Light and Heat for the Morton Hotel

IN THE PLAN VIEW of the Morton Hotel power plant on page 302 in the March 1 issue, the refrigeration room layout appears as it was originally designed for a compression system. This is incorrect, as it was afterwards changed to contain an absorption type ice plant, furnished by Carbondale Machine Co., as described in the article. No drawing of this absorption equipment was available when the article was prepared and the discrepancy between drawing and text was the result of an oversight in labeling the equipment on the drawing. On page 304 in the same article, the second sentence in the left hand column should read, "Figure 6 shows some of the parts of this system, the machine covered with frost being the brine pump."

THE INTERNATIONAL PAPER CO. is speeding up its construction work near Ottawa where the so-called Chelsea power plant is being constructed. The storage dam is located about 100 mi. up the upper waters of the Gatineau from the plant and a site is also to be harnessed below the Farmers Rapids site. These two combined will generate some 180,000 hp. and the cost of the entire development is estimated at from $18,000,000 to $20,000,000. Four specially constructed paper machines, the largest in the world, are being built by the Dominion Engineering Co. and will turn out sheets of paper approximately 20 ft. wide.



ELECTRICAL MACHINERY FOR LIGHT AND POWER

Transmission and Distribution Lines---IV*

CONCLUDING NOTES—METHODS OF PROTECTING AGAINST TROUBLE DUE TO SHORT CIRCUITS, LIGHTNING OR GROUNDS. BY STEPHEN Q. HAYES†

ON MODERATE voltage distribution systems of large capacity, the current that will tend to flow over the distributing cables in case of a short is liable to reach dangerous proportions and may wreck any regulators or other equipment in that particular circuit.

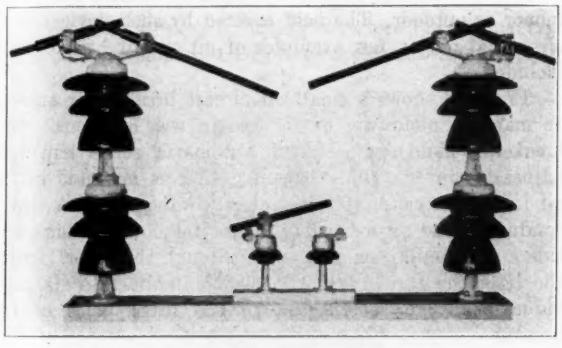


FIG. 1. OUTDOOR EXPULSION FUSES

To guard against trouble arising from such causes and to limit the drop in busbar voltage in case of feeder trouble, current limiting reactors have been furnished for many important installations. These reactors usually consist of long windings of heavy copper cable in the form of layers so arranged as to obtain the maximum reactance from the minimum amount of material. These reactors are usually wound on open frames to provide suitable cooling and they have no iron in their magnetic circuits. The successive layers are insulated from each other by suitable cleats of wood, porcelain or moulded compound or the individual layers are separate by being moulded into a concrete block. Because of the severe mechanical stresses between turns on these reactors during trouble conditions it is necessary to make them very rigidly constructed and braced to withstand shocks.

A 5 per cent reactor in a particular circuit limits the short circuit current to 20 times full load, so that on a 100 amp. feeder the maximum short circuit current, if 5 per cent reactors are used, would be 2000 amp., whereas that feeder connected to a large power plant, if no reactors were used, might be subjected to currents of 100 times normal, or more. Reactors are usually located in outgoing lines since most troubles originate outside the station and the flow of power to such a feeder is much less than if the reactor were placed in the generator circuit. Reactors are very carefully designed, both from electrical and mechanical standpoints, and are made as single phase units or three-phase, depending upon conditions.

PROTECTION OF DISTRIBUTION AND TRANSMISSION LINES

In considering distribution and transmission lines, the question of their protection from damage due to overload conditions, lightning, etc. must be considered at least briefly. To do this in a thorough manner would involve a fairly complete treatise on switches, fuses, carbon circuit breakers, oil circuit breakers, relays, lightning arresters, choke coils and other devices. The inclusion of much material on these subjects would make this article unduly long, so a few typical devices have been selected for illustration and description.

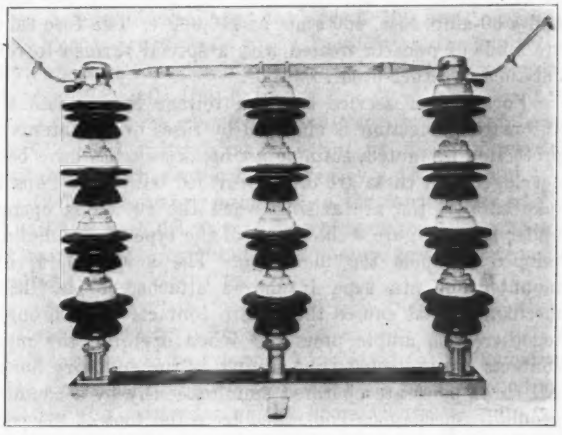


FIG. 2. 154-KV. AIR BREAK SWITCH

For low voltage circuits of moderate capacity, knife switches are used and automatic protection is obtained by means of fuses. The original fuses were small wire or strips of copper, aluminum, lead or alloy with a low melting point. The fire risk and other drawbacks of such open fuses led to their replacement by enclosed fuses or the use of special fuse blocks or holders.

These fuse holders can be made suitable for indoor or outdoor service and many types have been developed. Figure 1 shows two sizes of expulsion fuses arranged for outdoor mounting in the upright position. The smaller block is intended for service at 4500 v. and a 1-amp. fuse in this

*The preceding articles of this series appeared in the issues of December 15, 1925, February 1, 1926, and March 1, 1926.

†General Engineer, Westinghouse Electric and Mfg. Co., East Pittsburgh, Pa.

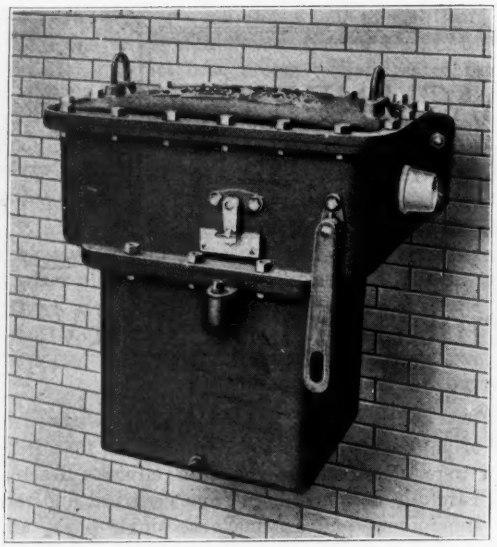


FIG. 3. SUBWAY TYPE OF OIL CIRCUIT BREAKER

holder will interrupt 10,000 amp. at 4500 v. and a 60-amp. fuse, 7000 amp. The larger holder is intended for service at 110,000 v. and a 1-amp. fuse will interrupt 600 amp. and a 60-amp. fuse, 400 amp. at 110,000 v. The fuse tubes are made of micarta treated with a special varnish to render them weather-proof.

For outdoor service on high voltage lines where the automatic protection is obtained by fuses or no automatic protection is wanted, suitable air break switches have been developed and these are often provided with horn gaps to take care of the arc arising when the switch is opened under load. Figure 2 shows one of the type of switches developed for pole top mounting. The switch parts are mounted on pin type insulators attached to a tilting mechanism that causes their main contacts to be brought together with ample pressure. When opening, the main contacts are protected from arcing by the auxiliary horns. All three poles are operated simultaneously by a common grounded mechanism controlled from the foot of the pole.

For heavy currents at low voltage, carbon circuit breakers or oil circuit breakers are used, while for the higher voltages, oil circuit breakers are almost invariably utilized. These oil circuit breakers are made in various current and voltage ratings for hand or electric operation, indoor or outdoor. The field covered by such devices is so large that only a few examples of oil circuit breakers are included.

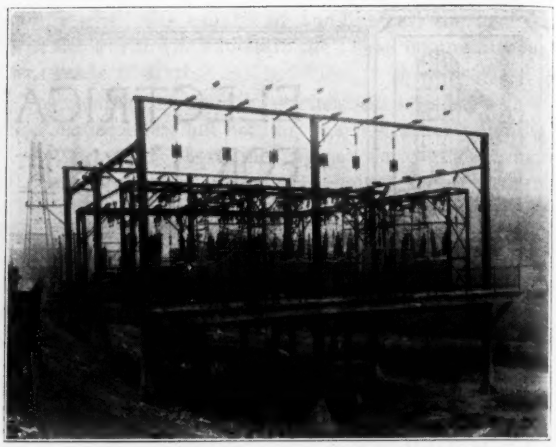


FIG. 5. OUTDOOR SWITCHING STATION

Figure 3 shows a small oil circuit breaker for subway or manhole mounting or for use in wet locations. This breaker is hand operated, full automatic, series trip with adjustable inverse time element dash pots mounted in the oil inside the case. It is completely waterproof. A three-conductor lead-covered cable can be taken in through one side and a similar one taken out through the other. Inside the tank the three-conductor cable is split into its individual leads for connection to the three poles of the breaker.

Figure 4 shows a small three-pole oil circuit breaker in an outdoor weather proof tank. This type of breaker is particularly well adapted for controlling lines where they enter buildings, for controlling branch lines, for sectionalizing feeders, for cutting off transformers or for similar duties where an outdoor form of breaker can be used to advantage on the distribution system.

For power circuits of heavier capacity, larger oil circuit breakers of the indoor or outdoor type are used. Figure 5 shows an outdoor switching station using large, round tank, floor mounting oil circuit breakers, electrolytic light-

FIG. 4. WEATHERPROOF TYPE OIL CIRCUIT BREAKER

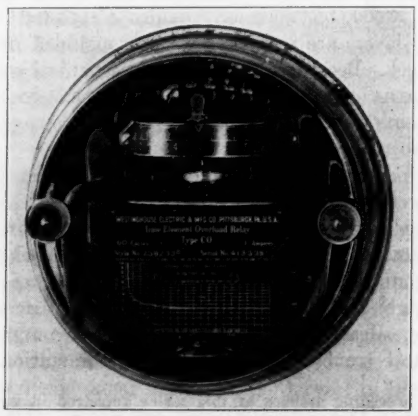


FIG. 6. OVERLOAD TIME LIMIT RELAY

ning arresters, choke coils and other high tension equipment. Owing to frequent flood conditions at this particular location all of the equipment is mounted on a concrete platform.

To obtain the automatic functioning of oil circuit breakers, series trip coils operated directly, or through series transformers, have been used. To get greater selectivity and to furnish brains to the oil circuit breakers, relays of various types have been developed. Figure 6 shows an induction type of relay giving overload protection and having an adjustable definite minimum inverse time limit feature. A discussion on the theory and operation of relays would require more space than is available in this article, but it may be said that suitable relays are available to give any desired characteristics to the circuits that are being controlled.

In addition to protection against excess current conditions secured by fuses or breakers with proper equipments of relays, it is usually necessary to protect transmission and distribution lines against lightning or other static disturbances.

Lightning Arresters

For such service, lightning arresters of various types have been developed. One of the most successful types of

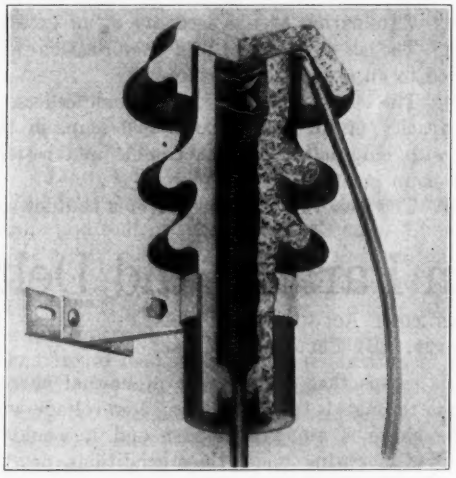


FIG. 7. 7500-V. AUTOVALVE ARRESTER

arresters developed for this service has been the aluminum cell electrolytic type that has been frequently described in the technical press.

A later type of arrester, particularly suited to distribution lines is the autovalve arrester*, Figure 7. This arrester, for distribution service, consists of a series of resistance disks in a porcelain casing from which leads of weather-proof insulated wire are brought out for the line and ground connections. The number of disks is chosen so as to make the voltage of discharge only slightly above the peak value of maximum rated line voltage, thus giving close protection. The disk area is large enough to make the total resistance of the disk structure exceedingly low. The properties of this arrester are such that the discharge at over-voltage is in the form of a glow discharge and no power current follows. This type of arrester is available up to 37 kv.

*The theory of the Autovalve arrester was described on page 374 of the March 15th issue.

For station service, where greater discharge capacity is wanted, there are four columns of resistance disks in parallel in a porcelain block and a sufficient number of blocks in series will permit this design to be utilized for any voltage. Both indoor and outdoor types of these station arresters are available.

This article has attempted to touch on most of the important features connected with distribution and transmission lines, but space limitation necessarily makes many of the descriptions rather meagre and causes certain features to be completely overlooked in the description.

Economy Due to Power Factor Correction*

By E. N. Dittenhofer†

IN A FULL-FASHIONED hosiery mill the average load conditions are bad, due to the operation of a large number of small induction motors—generally of 1.5 hp., which operate at an average power factor of from 30 to 40 per cent.

These conditions were especially bad at the plant of the Gotham Silk Hosiery Co., as was evidenced by an overall power factor of only 49.9 per cent. The feeder circuits were badly overheated and there was an excessive blowing of fuses. On one circuit in particular a 300 amp. fuse had been substituted for one of 100 amp. and even this blew several times a week. In addition, the two transformers were considerably overheated and there was grave danger of a costly shut-down.

At this time the load conditions were as follows:

(1) 106 knitting machines on six floors of two old buildings—each floor being driven by a 15-hp. motor.

(2) 21 knitting machines on the fourth floor of No. 2 building, each driven by a direct connected 1.5-hp. motor. It was on this circuit that the 300-amp. fuses had been installed.

(3) 85 knitting machines, in a new ten-story reinforced concrete mill, also driven by 1.5-hp. motors. This load was to be eventually increased to 168 machines. One circuit fed the floors from the sixth to the second and another the remainder of the floors. These circuits consisted of 500,000 cir. mil. cables with panel boxes on each floor and No. 8 wire feeders to each group of four motors —of which there were six on a floor.

(4) A miscellaneous load in the machine shop, winding room, on the elevators, and the like.

Conditions in January, 1924, especially in the new mill, became so bad that although only about one-half of the proposed load was running it was found necessary to take the six group drive floors off central station service and drive them with an old 75-hp. steam engine. This was done on the advice of the Philadelphia Electric Co. and relieved the transformers sufficiently to remove all danger of a shut-down.

Two plans for correcting the power factor of the mill were suggested. The first proposed to raise the power factor to the required 90 per cent by the installation of a group of static condensers at the metering point; the second proposed to install individual condensers on all the direct drive machines and then to add whatever additional correction was necessary at the metering point.

In view of the fact that it would have proved neces-

*Presented at meeting February 16, 1926, Engineers Club, Philadelphia, Pa.

sary to install a new feeder in the mill at a cost of about $1400 unless at least some of the correction was applied at the motor terminals, the latter plan was adopted.

The engineers of the National Electric Condenser Company proposed to install 1.5 kv.a. of correction on each of the 1.5-hp. motors to raise their power factor to 65 per cent and to install 120 kv.a. in group correction at the metering point. This would then raise the mill power factor to 90 per cent when the plant was entirely equipped with machinery.

The first step made was to install 78 kv.a. in individual condensers at the end of the feeders in the new mill and on the 21 machine feeder in No. 2 mill. After this had been done it was found possible to put back the six floors on central station service and to replace the 300-amp. fuse with the original 100-amp. installation. The load in the new mill had increased 16 machines by this time and after an additional 93 kv.a. in individual condensers had been installed the two 100 kv.a. transformers had cooled down to 159 and 169 deg. F. respectively with a room temperature of 85 deg.

The mill power factor had now been raised from 49.9 per cent to 70.3 per cent.

Before any group correction was installed, it was decided to run a test on the group drive motors in the old mills and the load was found to be badly overmotored and to be operating at a power factor of only 52.7 per cent. The six 15 hp., 900 r.p.m. motors were replaced by two 10 hp. and four 7.5 hp., 1200 r.p.m. motors with a saving of 40 hp. in a 90 hp. load. These new motors were corrected with 9.5 kv.a. in condensers applied at their terminals which raised their power factor to slightly better than 91 per cent. This motor change eliminated 37 kv.a. in group correction as originally planned.

By this time there was a total of 156 machines running in the three mills—individually driven—205 kv.a. in static condensers had been installed, and the plant power factor was 87.8 per cent.

A study of the motor driving the direct connected machines was next made and it was found that motors with different characteristics than those supplied with the machines could be purchased which with 1.5 kv.a. in condensers applied at their terminals would give a power factor of better than 90 per cent. The use of such motors on the remainder of the machines to be installed plus the installation of 20 kv.a. in individual condensers split between the winding room, the machine shop, and the elevators would entirely eliminate the necessity of any group correction at the metering point.

The last test made by the Philadelphia Electric Co. showed an overall power factor of 91.4 per cent.

The beneficial results obtained by the raising of the power factor from 49.9 to 91.4 per cent may be summarized briefly as follows:

(1) The elimination of the power factor penalty. This amounts to about $3600 a year and is alone a splendid return on the company's investment.

(2) A lower power consumption per unit of product.
(A) Kw.-Hr./Doz. Hose — Before = 0.63879.
(B) Kw.-Hr./Doz. Hose — After = 0.46047.

(3) Elimination of the necessity of an extra feeder.

(4) The showing up of bad motorization which in itself led to an appreciable saving.

(5) The cooling of transformers and feeders. Lower fuse capacity (from 800 amp. to 600 amp. in the new mill) with elimination of fuse trouble and better plant operation in general.

(6) The removal of all danger of a shutdown.

Dissimilar Transformers in Parallel and Delta

SUCCESSFUL PARALLEL OPERATION DEMANDS THAT ACCOUNT BE TAKEN OF VOLTAGE RATIO, IMPEDANCE AND POLARITY. BY FRED C. DEWEESE*

FOR SUCCESSFUL parallel operation of transformers, three things are essential. Their voltage ratios must be equal; their impedances should be inversely proportional to the loads which they are to carry and they must be so connected that their polarities will be identical.

EFFECT OF VOLTAGE RATIO ON PARALLEL OPERATION

As an illustration of what happens when transformers having a difference in their voltage ratios are connected in parallel, below is given an example of an experiment made with two transformers having the following characteristics: 1—333 kv.a., 13,200/2300 v., impedance 6.77 per cent. 1—75 kv.a., 13,200/2200 v., impedance 1.83 per cent. It will be seen that the difference in voltage of the two transformers is 4.35 per cent, from the fact the low voltage of one transformer is 2300 v. and of the other 2200 v.

The circulating current that will flow in the windings may be determined from the following equation:

$$\text{Per cent I} = \frac{\text{Per cent Voltage Difference}}{\text{Sum of Per cent Impedances}} \times 100 \quad (1)$$

Substituting the known values in 1, we have

$$\text{Per cent I} = \frac{4.35}{1.83 + 6.77} \times 100 = 50.6 \text{ per cent}$$

This means that 50 per cent of normal current will circulate through both the high and low voltage windings.

The above is an extreme case and it would not be thought of operating under these conditions, nevertheless, if the voltage ratios have a difference of only 1 per cent, the circulating current will be—

$$\frac{1}{1.83 \times 6.77} \times 100 = 11.6 \text{ per cent.}$$

It is not practicable to attempt to operate transformers with only slightly different voltage ratios in parallel, unless it would possibly be of large units, for the expense of balance coils for compensating for the difference in voltage would be prohibitive for installations of small capacity.

In addition to identical voltage ratios and polarities, for successful parallel operation, it is, as stated above, necessary that the transformer impedances be inversely proportional to the loads which they are to carry. The voltage drop must necessarily be the same in all the units when connected in parallel, and necessarily a circulating current must flow in unlike transformers in order to equalize the voltage drop.

Due to the difference in phase between the currents in the unlike transformers, the sum of the individual currents will be greater than the line current; however, unless the phase difference is greater than about 15 deg., the small

*Engineer. Distribution Dept., Louisville Gas & Electric Co.

difference in relative resistance and reactance may safely be neglected and only the total impedance be considered.

Impedance of a transformer is expressed as the voltage drop in per cent of normal voltage at normal load. It is the resultant of two components; the voltage drop due to the ohmic resistance of the windings and the voltage drop due to the magnetic leakage between the high and low voltage windings. The resistance drop is in phase with the current and the reactance drop is 90 deg. out of phase with the current.

For finding the division of load between any number of transformers, or banks of transformers operating in parallel, the following formula may be used:

$$I_1 = \frac{\left(\frac{\text{Kv.a.}}{\%\text{IZ}}\right)_1}{\left(\frac{\text{Kv.a.}}{\%\text{IZ}}\right)_1 + \left(\frac{\text{Kv.a.}}{\%\text{IZ}}\right)_2} \times I_L \qquad (2)$$

Where I_1 = the load current in transformer number 1.
I_2 = the load current in transformer number 2.
I_L = the line current for any given load.

As an example, we will assume a load of 333 + 75 = 408 kv.a. and connect in parallel the two transformers which we have been discussing, except that we are to assume equal voltage ratios. The line current for 408 kv.a. at 2300 v., single phase, will be 177 amp.

$$I_1 = \frac{333/6.77}{333/6.77 + 75/1.83} \times 177$$
$$= 49.2/90 \times 177 = 96.6 \text{ amp.}$$
$$I_2 = 41/90 \times 177 = 80.6 \text{ amp.}$$

The full load current rating of transformer number 1 is 145 amp. and that of number 2 is 33 amp. Thus, it is shown that under the above conditions, the load on number 1 is only 66 per cent of its normal rating and the load on number 2 is 241 per cent of its normal rating, which, of course, is an impossible operating condition.

The maximum load which this combination of transformers could carry without overloading the smaller transformer, may be determined by substituting in equation 2, the full rated current for transformer number 2 and solving for I_L.

$$33 = 41/90 \times I_L \text{ whence } I_L = \frac{90 \times 33}{41} = 72.44 \text{ amp.}$$

This is equal to $2300 \times 72.44 = 167$ kv.a., single phase, which is only 50 per cent of the rated capacity of the larger transformer.

While, as stated above, this is an extreme case, it shows very clearly what could happen under certain conditions. What would seemingly be an additional load carrying capacity only serves to reduce the capacity.

If it is desired to make the solution more accurate, it will be necessary to know the value of the resistance volts drop and the reactance volts drop in per cent, for each transformer. This information can usually be obtained from the manufacturer of the transformers, but if the time required to secure the above-mentioned information is an important factor, calculations can be made for determining the resistance volts and reactance volts, provided the efficiencies are known for two different loads and the impedance for each transformer is known.

We will assume, for example, that the efficiency at full load of the 333-kv.a. transformer is 98.2 per cent; efficiency at one quarter load is 96.6 per cent, and the impedance 6.77 per cent.

The input at full load will be 333/.982 = 339.1 kw., or 6100 watts loss. The input at ¼ load will be 83.25/.966 = 86.18 kw., or 2930 w. loss.

Let X equal the iron loss at all loads.

And Y equal the copper loss at full load.

The copper loss is proportional to the square of the load.

Then:

$$X + Y = 6100 \text{ watts} \qquad (3)$$
$$X + Y/16 = 2930 \text{ watts} \qquad (4)$$

Clearing (4) of fractions

$$16X + Y = 46{,}880$$

Subtracting (3) from (4) $\quad X + Y = 6{,}100$

$$15X = 40{,}780$$
$$X = 2719 \text{ watts, iron loss}$$
$$Y = 6100 - 2719 = 3391 \text{ watts,}$$

copper loss. The resistance volts are equal to

$$\frac{3.391}{333} \times 100 = 1.01 \text{ per cent.}$$

The reactance volts are equal to

$$\sqrt{(6.77)^2 - (1.01)^2} = 6.69 \text{ per cent.}$$

The calculations for the other transformer may be made in the same manner.

When the above values are known the division of load may be computed as follows:

Let θ_1 be the angle between I_1R_1 and I_1Z_1 and θ_2 be the angle between I_2R_2 and I_2Z_2.

Then: $$\text{Cos}(\theta_1 - \theta_2) = \frac{R_1R_2 + X_1X_2}{Z_1Z_2} \qquad (5)$$

$$(\text{Kva})_1 = \frac{(\text{Kva})_2}{\sqrt{\left[1 + \frac{(\text{Kva})_2 \%Z_1}{(\text{Kva})_1 \%Z_2} \times \text{Cos}(\theta_1 - \theta_2)\right]^2 + \left[\frac{(\text{Kva})_2 \%Z_1}{(\text{Kva})_1 \%Z_2} \times \text{Sin}(\theta_1 - \theta_2)\right]^2}} \qquad (6)$$

$$(\text{Kva})_2 = \frac{(\text{Kva})_2}{\sqrt{\left[1 + \frac{(\text{Kva})_1 \%Z_2}{(\text{Kva})_2 \%Z_1} \times \text{Cos}(\theta_1 - \theta_2)\right]^2 + \left[\frac{(\text{Kva})_1 \%Z_2}{(\text{Kva})_2 \%Z_1} \times \text{Sin}(\theta_1 - \theta_2)\right]^2}} \qquad (7)$$

$R_1 = 1.01$ percent; $R_2 = 0.83$ percent.
$X_1 = 6.69$ percent; $X_2 = 1.83$ percent.
$Z_1 = 6.77$ percent; $Z_2 = 1.93$ percent.

From (5) $\text{Cos}(\theta_1 - \theta_2) = \frac{(1.01 \times 0.83) + (6.69 \times 1.83)}{6.77 \times 1.93} = 0.9478$

$\text{Sin}(\theta_1 - \theta_2) = 0.319$

The angle between the current in transformer number 1 and transformer number 2 is, therefore, 18.6 degrees.

From (6)

$$(\text{Kva})_1 = \frac{408}{\sqrt{(1 + 75 \div 333 \times 6.77 \div 1.93 \times .9478)^2 + (75 \div 333 \times 6.77 \div 1.93 \times .319)^2}}$$
$$= \frac{408}{\sqrt{(1.789)^2 + (0.266)^2}}$$
$$= \frac{408}{1.809} = 225.66 \text{ Kva.}$$

From (7)

$(\text{Kva})_2$ is computed to be 187.84 Kva.

We now have a total load kva, if added arithmetically, equal to 225.66 187.84 = 413.5 kva. But, in order to make this check with the actual kva. load, we must take into account the phase angle between I_1 and I_2, which is 18.6 degrees.

$$(\text{Kva})_2 = \sqrt{(\text{Kva})_1^2 + (\text{Kva})_2^2 + 2(\text{Kva})_1 \times (\text{Kva})_2 \times \text{Cos}(\theta_1 - \theta_2)^2}$$
$$= \sqrt{(225.66)^2 + (187.84)^2 + 2(225.66 \times 187.84 \times 0.9478)^2} = 408$$

Now refer back to the first method, and we have $(\text{Kva})_1 = 2300 \times 96.6 = 222.18$ kva. $(\text{Kva})_2 = 2300 \times 80.6 = 185.38$ kva.

The percentage of error by using the impedance values only is 1.1 percent for number 1 transformer and 1.3 percent for number 2 transformer. This would indicate that the longer and more accurate method is not justified in this case, and will seldom ever be for standard transformers.

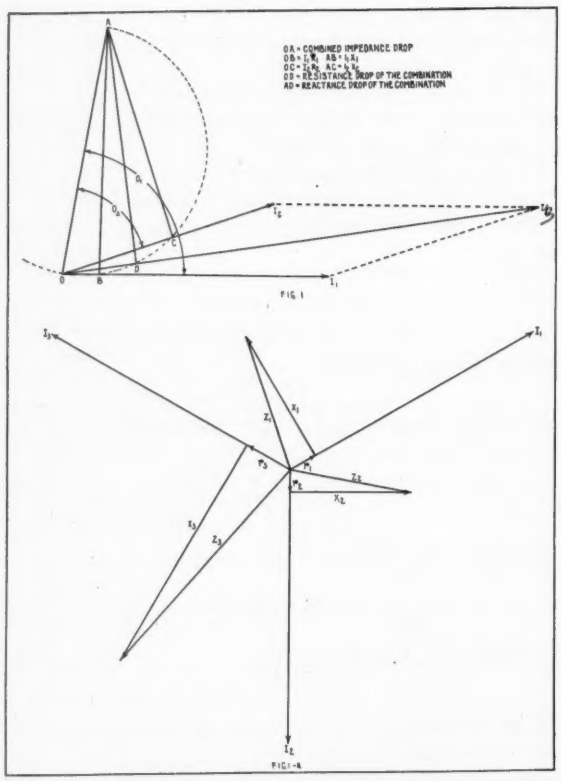

OA = COMBINED IMPEDANCE DROP
OB = I1R1 AB = I1X1
OC = I2R2 AC = I2X2
OD = RESISTANCE DROP OF THE COMBINATION
AD = REACTANCE DROP OF THE COMBINATION

FIG. 1. VECTOR DIAGRAM SHOWING CONDITIONS FOR TWO TRANSFORMERS CONNECTED IN PARALLEL

FIG. 1A. DIAGRAM FOR THREE DISSIMILAR TRANSFORMERS CONNECTED IN DELTA

Vector Solution

Figure 1 is a vector diagram which shows the conditions for the two transformers of the previous example, when connected in parallel.

To construct this diagram, lay off OA to represent the impedance drop in the two transformers, to some convenient scale. The scale is unimportant as long as the same ratios are followed throughout. Lay off OB, to represent I_1R_1 to the same fraction of OA as I_1R_1 bears to to I_1Z_1. Now lay off OC to represent I_2R_2 and to the same fraction of OA as I_2 R_2 bears to I_2Z_2. If the work is carried out accurately the angle between OB and OC should be 18.6 deg. Draw I_1 and I_2 and add them vectorially when we obtain I_3. OD and AD represent respectively the IR drop and IX drop of the combination.

In the vector OA is 4.5 in., then OB is determined as follows:

$$\frac{4.5}{OB} = \frac{6.77}{1.01} \quad OB = 0.67 \text{ in.}$$

And

$$\frac{4.5}{OC} = \frac{1.83}{0.83} \quad OC = 2.04 \text{ in.}$$

Effect of Connecting Dissimilar Transformers in Delta—Vector Solution*

Suppose it is desired to connect three unlike transformers in closed delta and see what will happen.

We will assume that two 500-kv.a. and one 333-kv.a. transformers are connected in delta. The two 500-kv.a. transformers will be referred to as numbers 1 and 2 and the 333-kv.a. will be referred to as number 3.

The resistance volts drop of 1 and 2 are respectively 1 per cent and 0.8 per cent and that of 3 is 1.2 per cent. The reactance volts are respectively 5 per cent, 4.5 per cent and 6 per cent.

It is necessary to refer the kv.a. rating to the same load basis, or in this case, 500 kv.a.

The resistance volts drop in per cent, for the number 3 transformer, as referred to a 500-kv.a. basis is equal to

$$1.2 \times 500/333 = 1.8 \text{ per cent.}$$

The reactance volts drop is equal to

$$6 \times 500/333 = 9 \text{ per cent.}$$

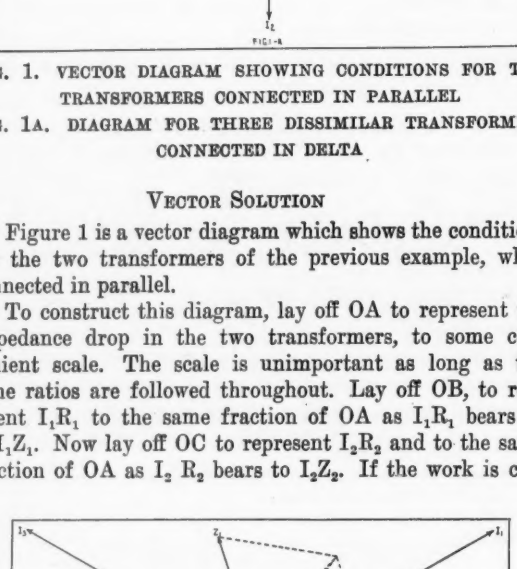
$$R = r_1 + r_2 + r_3 = 1 + 0.8 + 1.8 = 3.6 \text{ per cent.}$$

$$X = x_1 + x_2 + x_3 = 5 + 4.5 + 9 = 18.5 \text{ per cent.}$$

$$Z = \sqrt{R^2 + X^2} = \sqrt{(3.6)^2 + (18.5)^2} = 18.84 \text{ per cent.}$$

As in Fig. 1A lay off I_1, I_2 and I_3 at angles of 120 deg. representing balanced three phase currents of 100 per cent. This should be laid off very carefully to scale, if the final results are to be accurate. It is convenient to make the current scale about ten times as large as the voltage scale, then 100 per cent current will equal 10 per cent voltage drop.

*For method of vector solution refer to an article by J. B. Gibbs, Electric Journal, March, 1925, page 121.



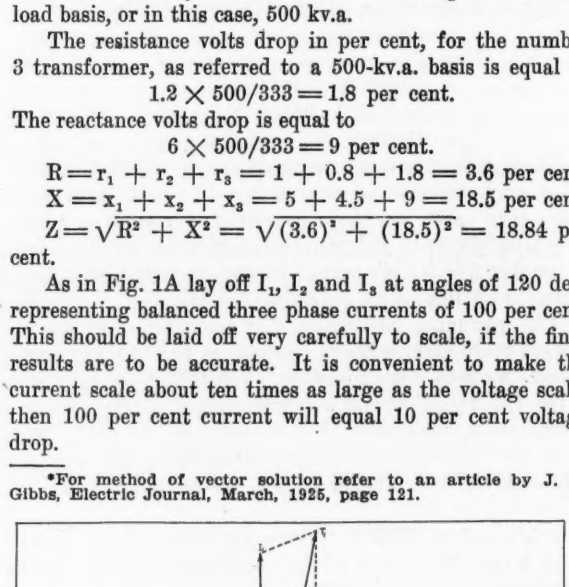


FIG. 2.-3. FURTHER STEPS IN THE SOLUTION OF PROBLEM STARTED IN FIG. 1A

Lay off r_1 along I_1 and equal to 1 per cent. Lay off x_1 from the point of, and at right angles to r_1. Draw in z_1. Follow the same procedure with r_2, r_3, x_2 and x_3.

Now refer to Fig. 2, in which the 100 per cent load currents are laid out as before. Lay off z_1, z_2 and z_3 and add them vectorially, when we obtain $z_1 + z_2 + z_3$. Draw E_s equal and opposite to the sum of z_1, z^2 and z_3 and scale 4.32 per cent.

The impedances of the three transformers, as previously shown, is 18.84 per cent, which is the voltage, in per cent, required to circulate full load current through the transformer windings. But E_s is 4.32 per cent and from this the circulating current will be

$$\frac{4.32}{18.84} \times 100 = 23 \text{ per cent of full load current.}$$

The circulating current, which we will designate, as I_c, lags behind E_s the angle whose tangent is equal to X/R, $= 18.5/3.6 = 5.14$, the angle being 79 deg.

As in Fig. 3, lay off I_c, to the same scale as I_1, I_2 and I_3 and at an angle of 79 deg. from E_s in a lagging direction. This represents the circulating current both in phase and magnitude. I_c is added vectorially to I_1, I_2 and I_3, and the resultants T_1, T_2 and T_3 obtained.

T_1, T_2 and T_3 represents respectively the per cent of normal full load current in transformers number 1, 2 and 3, based on a 500 kv.a. rating for each transformer.

T_1 scales 108 per cent; T_2 scales 111 per cent and T_3 scales 80 per cent. But transformer number 3 is only 333 kv.a. therefore, its current is

$80 \times 500/333 = 120$ per cent of its normal full load rating.

The total load that the bank will carry without overloading either of the transformers is equal to

$$1500 \times 100/120 = 1250 \text{ kv.a.}$$

As a check on the above, if we are to reduce the load on the 333-kv.a. transformers to 100 per cent we must reduce 120 by 16.66 per cent. This will bring the load from 400 kv.a. to 333 kv.a. Accordingly, it is necessary to reduce the load on the other two transformers by a like percentage. Thus,

$108 \times .8334 = 90.84$ per cent.
$111 \times .8334 = 92.507$ per cent.
$500 \times 90.84 = 454.2$ kv.a.
$500 \times 92.507 = 462.5$ kv.a.
$454.2 + 562.5 + 333 = 1249.7$ kv.a., for the total capacity of the bank.

The reader will probably say, "why did not the writer use for an example, as given in the first part of the article, a more practical problem"? In answer to this, I will say that many people are of the opinion that when you connect an additional transformer in parallel with another, or other transformers, you are securing that much more load carrying capacity, when as a matter of fact, this example proves very conclusively that such is not always the case. The purpose of the article is to show the method of calculation only, no attempt being made to obtain extreme accuracy, a slide rule being used for most of the work.

Proper First Aid Treatment Saves Many Lives*

Care of First Aid Kit and Proper Use of Material It Contains Are Necessary for Proper Preliminary Treatment of Accidents

IN SPITE OF the fullest co-operation between the management and those of us working under their direction toward the avoidance of accidents, we must all recognize that some accidents will occur either while we are on the job or at our homes, therefore we should be always prepared to care for them. Benefits that may be derived through a knowledge of first aid are: (1) In the case of minor injuries it is possible to prevent serious consequences, such as blood poisoning; (2) In the case of a serious accident, the patient will not suffer unnecessary pain because of improper handling and will be kept in the best possible condition so that the doctor's services, when he arrives, will be most effective.

Maintenance of First Aid Kits

Let's first consider how to keep these first aid tools of ours in good working order. The pasters on the inside of the cover of the first aid box provided by the company (in the large box, it is on the inner cover) show just how each article should be placed in the kit. Familiarize yourself with the arrangement and know just where each article is to be found. Then be sure it is *always kept there.* At some time you may want an article in a hurry and want it badly. To have the article you want readily available for the emergency you must always keep a sufficient supply of articles in the kit. When a bandage, swab or other item is used, replace it with a new one just as soon as you can.

The absorbent gauze compress has two principal uses: (a) as a compress over a large wound or burn properly treated; (b) as padding for splints in case of a fracture. When used as a compress over a large wound or burn, the absorbent gauze should be held in place by a triangular bandage folded as a cravat bandage or by a 2½ or 6-in. bandage. When the absorbent gauze compress is used to pad a splint, it should be folded to a size such that when placed over the splint, it will overlap each edge by about an inch or two.

Figure 1 shows how to unfold an absorbent gauze compress for the various uses and Fig. 2 shows how it should be used.

The triangular bandage should never be placed directly on a wound or burn because it is difficult to handle the bandage and keep it free from germs. It is most commonly used: (a) as an arm sling, Fig. 2; (b) as a folded or cravat bandage to hold a compress securely in place, to hold splints in place, at a joint to hold a compress in place, as an eye bandage, a groin bandage, over a broken rib, etc., Figs. 2, 4 and 5; (c) as a head bandage to keep a compress in place; (d) as a bandage over a compress on a wound on the shoulder or hip; (e) as a hand or foot bandage covering a compress applied to the wound.

The uses for the 1-in. and 2½-in. bandages are alike, except that the 1-in. is to be used on smaller parts of the body than the 2½-in.; for example, on the fingers or

*Abstract of 1925 Serial Report of N.E.L.A. Accident Prevention Committee. The report is called "First Aid Talks" and is not intended for use as a textbook by those studying first aid, but as a guide for those who are teaching the subject.

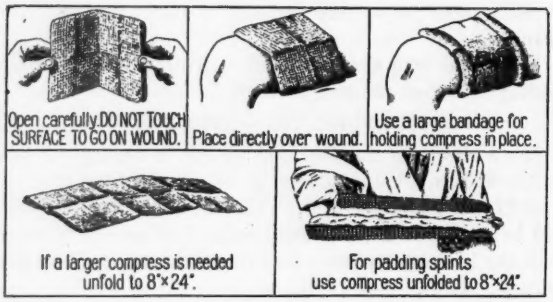

Open carefully. DO NOT TOUCH SURFACE TO GO ON WOUND.
Place directly over wound.
Use a large bandage for holding compress in place.
If a larger compress is needed unfold to 8"×24".
For padding splints use compress unfolded to 8"×24".

FIG. 1. THE ABSORBENT GAUZE COMPRESS AND A FEW OF ITS USES

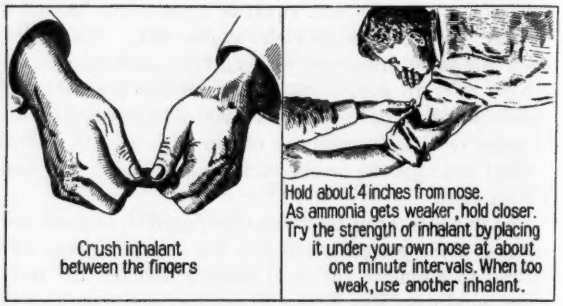

Crush inhalant between the fingers
Hold about 4 inches from nose. As ammonia gets weaker, hold closer. Try the strength of inhalant by placing it under your own nose at about one minute intervals. When too weak, use another inhalant.

FIG. 3. AMMONIA INHALANT FOUND IN FIRST AID KIT IS USED AS A STIMULANT

toes, while the 2½-in. is for use on the hand, wrist, arm or leg. These bandages may be used: (a) to hold a small compress securely in place; (b) where necessary, to splice out the tails of a compress; (c) to hold padding in place on board splints.

In addition to these uses for both the 1-in. and 2½-in. bandages, the 2½-in. bandage alone may be used: (a) to hold the absorbent gauze compress in place, generally on the arm or the leg; (b) to wrap around the wire splints and hold them in place.

The Iodine Swabs

If we could always be sure that both the portion of our skin which is cut or scratched and the tool or material inflicting the wound were perfectly clean; i.e., free from germs, we would never have to use such a thing as iodine to kill the germs which may lead to infection and possibly blood poison; but, of course, these ideal conditions are impossible except during a properly conducted surgical operation. Therefore, we must always use an iodine swab to guard against infection whenever the skin is broken and bleeding is slight or in case of a scratch. After the iodine has killed the germs, we must prevent others from entering the wound by the use of a sterile compress, which is provided and which we have already discussed.

Ammonia Inhalants

When the patient is "knocked out" as a result of an injury, or has fainted and his face is *pale,* his heart action will usually be weak. The pulse, which can be felt in the wrist, temple, or neck, tells you how the heart is acting. A normal pulse beats 72 times a minute. If the pulse beats more slowly than this, or is weak, or if no pulse can be felt in the wrist the action is not normal and something should be done. An ammonia inhalant under these conditions, as in Fig. 3, will usually assist in bringing the heart action back to normal.

Borated Petrolatum and Carron Oil Tubes

The ointment contained in the tubes is to be used to apply directly to any type of external burn. Cover the burn with the ointment and then with a compress, and, if necessary, use a bandage to securely hold the compress in place, as in Fig. 4. Never apply iodine to a burn or put absorbent cotton over it. The iodine would irritate it and the cotton stick to it. In case a considerable portion of the body is burned some slight relief may be quickly given until the doctor arrives, by covering the burned surface with a sheet or cloths soaked in linseed or olive oil, if you can get it.

Type of Accident Determines First Aid Treatment

The kind of accident, the surrounding conditions and whether or not you have some one there to help you, all govern what you should do first in case of an accident. If you have to stop severe bleeding or restore breathing, get to work on these jobs right away and don't give up until you have completed the job or until a doctor comes and takes charge. These are about the only cases where you must rush the first aid work, and even in restoring breathing after you have gotten started, you mustn't hurry, but must continuously maintain the same speed in applying and releasing pressure. In all other kinds of injury, get right to work, but don't hurry. Be sure to do the work thoroughly.

In every serious case or every case where there is any doubt about its seriousness send for a doctor or ambulance at once, but if you are alone with the injured person, don't leave him to get the doctor until you have fixed him up.

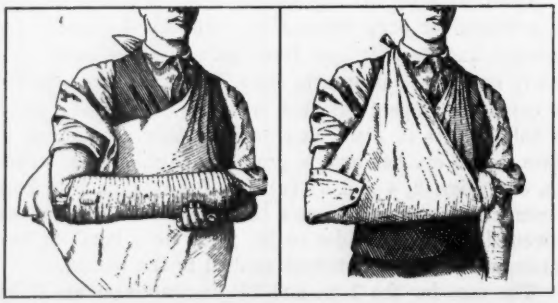


FIG. 2. METHOD OF USING COMPRESSES, SPLINTS AND THE TRIANGULAR BANDAGE AS AN ARM SLING

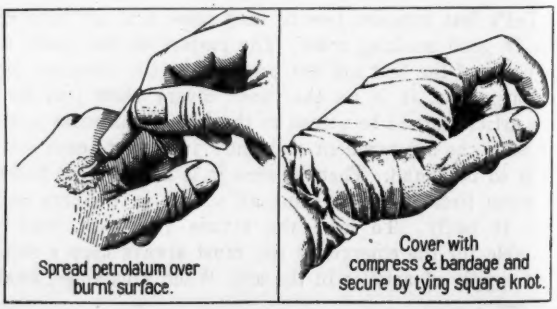


FIG. 4. FOR SMALL BURNS, USE PETROLATUM AS SHOWN HERE

The person who calls up or goes for a doctor or ambulance, should be able to tell: (a) the location of the injured person; (b) the cause of the injury, and, if possible, its nature; (c) what first aid is being rendered.

In giving the cause and nature of the injury, be as specific as you can; for example, information as to the approximate height a man has fallen and where you think he is injured, is of greater value to the doctor than the statement that the injured man fell from a pole. Don't take the injured person from the place where the doctor expects to find him, unless you have a mighty good reason. If you do take him away, have some one stay at the old location to tell the doctor where he can find his patient.

Treatment While Waiting for the Doctor

Examine the injured person carefully and see the injury clearly before you try to treat it. To do this it may be necessary to remove some clothing. This may be very painful and sometimes dangerous for the patient, unless he is handled gently. In removing outer clothing, rip it on a seam if possible. Cut or tear the underclothing carefully. If for some reason you decide to remove the clothing without cutting or tearing it, always take it off the sound side of the injured person first, so that the injured side may be moved as little as possible. Where necessary to remove boots or shoes in case of an injury to the foot or ankle, cut them off. During the time you are removing the clothing and rendering first aid, do not disturb blood clots, do not break blisters and do not excite the injured person or lead him to believe that he is badly hurt. While waiting for the doctor, if the injured person is unconscious but breathing all right and not bleeding severely, don't get excited and try to make him sit up or stand up; treat for faintness, as we shall explain later, and watch him carefully to see that he does not stop breathing and that severe bleeding does not recur.

If either of these two conditions do recur, get right to work again. A man who has been hurt is nearly always pale and the best position for him is on his back with his head low, unless this position will interfere with the treatment of the injury; however, if he is unconscious and his face is *red,* raise his head by putting a couple of folded coats, a rolled blanket or something of the kind under it.

Tight clothing may interfere with breathing or the blood circulation, so loosen the injured man's collar, belt and suspenders as soon as you can. If the patient is vomiting, turn him on his side or turn his head to one side so that his wind pipe will not be stopped up and choke him. Have someone keep the crowd back. They interfere with your work and shut off the supply of air to the injured man.

Unconsciousness

You may have to treat a person who is unconscious, without knowing what caused it. *Always* send for a *doctor* just as soon as you can without neglecting the patient. Some of the common causes of unconsciousness are: fainting, electric shock, gas asphyxiation and drowning, which we shall discuss later, heat exhaustion, sunstroke, apoplexy, fractured skull, knocked out by a blow, usually on the head or in the stomach, no bones being broken, alcoholic poisoning.

Try to determine the cause of the unconsciousness. Examine the patient carefully to discover an injury. You can nearly always pick out a case of electric shock, gas asphyxiation or drowning at once, because of the surrounding conditions. Some of the other causes may be a lot harder to determine.

If you can't find out the cause, be governed entirely in what you do by the color of the patient's face. If he is *pale,* lay him on his back with his head low. Stimulate him in the ways I have described for fainting. If his face is *red,* and the pulse strong, lay him down with his head raised. Don't stimulate, but sprinkle cold water on his face and chest or put cloths wet with cold water on his head and chest.

Stopping Severe Bleeding

When an artery is cut, bright red blood spurts from the wound and a large amount of blood may be lost in a very short time, causing the patient's death. So, the first thing to do is to stop the bleeding. A man can bleed to death in a minute if the great vessels of the neck or thigh are cut. An artery is a flexible tube, so that by pressing the sides together you can stop the flow of blood through it. To do this you must know where the artery lies close to the skin and over a bone against which it can be pressed.

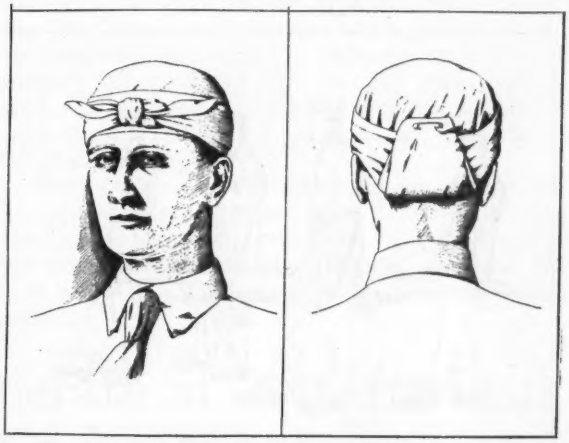


FIG. 5. TRIANGULAR BANDAGE IS USEFUL FOR BANDAGING HEAD WOUNDS

But there are times when it is impossible to find the source of the bleeding because of the large quantity of blood and the size and shape of the cut. In these cases, the first thing to remember is that the blood flow must be stopped at once. Direct pressure in the wound and over the blood flow must be made with the hand, first forcing into the wound any cloth available, which will serve as a pressure pad.

Difference Between Simple and Compound Fractures

When a bone is broken, the injury is called a fracture. Fractures are among the most frequently occurring injuries, happening about ten times as often as do dislocations. About two-thirds of all fractures are of the bones of the arms and legs. Next in frequency are those of the collar bone and ribs.

The two kinds of fractures that most frequently occur are: (a) a simple fracture, one in which the skin is not pierced and there is therefore no danger of infection; (b) a compound fracture, one in which there is an open wound leading down to the fracture. Because of the danger of infection and the damage done to the tissues

around the bone, a compound fracture is much more serious than a simple fracture.

In a case of simple fracture, send for a doctor at once. The principal object of the first aid treatment before the doctor arrives is to prevent the ends of the bones from puncturing the skin and so converting a simple into a compound fracture. Put the patient in a comfortable position and prevent the broken bone from moving.

If the broken bone must be moved slightly, either to make the patient more comfortable or while preparing to put on splints, support it firmly on each side of the break with your hand. Be sure not to let the bone bend at the break.

While waiting for the doctor, support the broken bone on a pillow or on folded coats, but in so supporting it, be sure it is not bent at the break. Watch the patient closely so that you can treat promptly for faintness, if it is necessary.

In case of a compound fracture, send for a doctor at once. Never attempt to set a broken bone. Expose the fracture by cutting away the clothing. Don't let the bone draw back into the flesh, as germs will be carried back with it and infection may result. Don't touch the wound with the fingers, nor wash it with water. Paint the exposed end of the bone, the wound and the surrounding skin with iodine. In painting the surrounding skin, spread the iodine from the wound outward. Cover the wound with a suitable compress held loosely in place. If the patient must be moved, use every precaution, as in the case of a simple fracture, to prevent movement of the parts of the broken limb. Watch the patient closely so that you can treat promptly for faintness, if it is necessary.

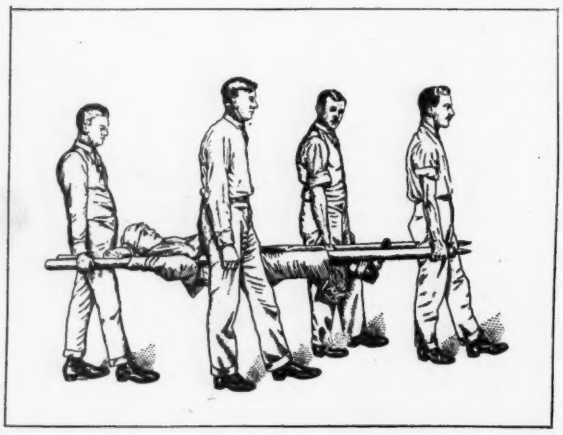


FIG. 6. METHOD OF CARRYING INJURED MAN ON STRETCHER IMPROVISED FROM PIKE POLES, COATS AND THE LIKE

Dislocations

General Knowledge Relative to Dislocations. When a bone gets out of place at a joint, it is called a dislocation. The joints are enclosed in flexible sacs and are held together by bands or ligaments. The sac and the ligaments are torn and injured when a dislocation occurs except in those cases where one of the bones at the joint has frequently been dislocated before.

A dislocation can usually be recognized at a glance because the joint is out of shape. If there is any doubt in your mind, compare it with a similar joint on the other side of the body. If you are still in doubt, notice the limited movement of the joint.

In general, no attempt should be made to reduce a dislocation except in cases of certain types which we will discuss later, because you will probably injure the small blood vessels, nerves and muscles around the joint if you do try, so send for a doctor at once. Place the patient in a comfortable position, cover the injured joint with cloths wrung out in very cold water, so as to contract the blood vessels and prevent swelling as much as possible. Treat the faintness that the patient will probably feel.

Some Common Injuries

If you get something in your eye, first try to remove it; if you can't get it out, go to see a doctor right away. Never pick at anything in the eye with a pencil, knife blade match or tooth pick. An eye is too valuable to take any chances with. If you have something in your eye, never rub it; you will just imbed the particle in the lid or eye ball.

First, close your eye so that the tears will accumulate and the particle will frequently be washed into view so that it may be removed readily with the corner of a piece of gauze. If this fails, pull the upper lid over the lower lid two or three times, close the nostril on the opposite side with your finger and blow your nose hard enough through the open nostril.

If the particle still remains in the eye, have someone examine first under the lower and then under the upper lid.

To remove a particle from the lower lid, have the patient look up, press the lower lid down and if the particle can be seen it should be brushed out with the corner of a piece of gauze.

To remove a particle from under the upper lid, seat the patient in a chair with his head hanging over the back. Stand behind him and place a match across the upper lid about ½ in. from its edge. Turn the upper lid up and back over the match and brush the particle out with a piece of gauze.

Hernia, or rupture, is the forcing of part of the intestines through the lower abdominal wall at or near that portion of the abdomen known as the groin. The force causing this to occur is the contraction of the muscles of the abdomen. Its occurrence immediately follows strain and is accompanied by pain and a feeling "that something has given way," at the same time a lump appears in the groin.

If the hernia occurs suddenly and persists, no matter what degree of strain caused it, a doctor should be called at once. The indications for an emergency doctor's call are four: (1) effort; (2) pain; (3) swelling and (4) disability. If the hernia occurs gradually and is manifested only by the swelling with no disability or pain, a doctor should be consulted at the earliest opportunity.

If disabled and suffering intense pain, employee should be placed on his back with his knees raised. Put one or more pillows under his knees and legs to keep them up. Place cloths, wet in cold water, over the hernia. This is done to prevent swelling and further difficulty in replacing the hernia. Wait for the doctor.

General Information. Never move or carry an injured man unless it is absolutely necessary and always try to render first aid before you attempt to carry the patient. It is necessary however, that you know how to transport

the patient, since his injuries may be greatly increased if he is not handled properly.

In general, the best way to carry an injured man is on a stretcher. A stretcher may be improvised from a number of things, such as jumpers, coats, burlap bags or blankets and a pair of pike poles as in Fig. 6. A shutter, door or ladder may also be used if you can get one, but whatever is used, be absolutely sure that it is strong enough to carry the injured man. Have one of the gang try it first.

Before lifting or carrying an injured man it is always best to tie his feet together. When lifting or carrying him one person should give all the orders and all should act together, thus relieving the jarring.

To lift the patient, three men should kneel at the one side of the patient on their knees nearer the patient's feet; i.e. on their right knees if on his right side and on their left knees if on his left side.

A fourth man should take a position on the opposite side of the patient with the stretcher, if one is available, so that he can slip it under the patient after the patient has been raised.

One Man Carry

If the injured person is conscious and his legs and one arm are not injured you can help him to walk by putting his uninjured arm over your shoulder and your arm around his waist.

If you have to carry an injured man without assistants, straighten his arms along his sides and turn him over on his stomach. Take a position astride his body, facing toward his head and grasp him under the armpits.

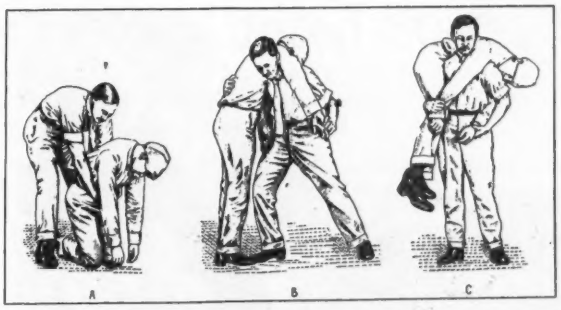


FIG. 7. HOW ONE MAN CAN CARRY AN INJURED MAN WITH THE LEAST DISCOMFORT

Continue to lift the injured man until he is in an upright position Fig 7A. Supporting the injured man with the lower part of your body, with your right arm around his waist, move to left. Grasp his left wrist with your left hand and throw his left arm over your shoulders, Fig. 7B. Move toward the front of the patient, blocking his knees with your right leg. Release your hold on the patient's left wrist and with your left hand grasp his right wrist, drawing his right arm over your head as you stoop slightly and resting his right arm on your left shoulder.

Stoop further. Remove your right arm from around the injured man's body and pass it between his legs, grasping his right wrist with your right hand and his left wrist with your left hand, Fig. 7C. Shift his body until it is well balanced on your back. Rise to an upright position.

Balch Hydro Plant to Operate at 2740-ft Head

First Unit of 500,000 hp. Hydro-Electric Project of San Joaquin Light and Power Corp., Fresno, Calif., Now Under Construction

DESIGNED TO OPERATE under an ultimate static head of 2470 ft.—nearly half a mile—the Balch hydro-electric power station now under construction on Kings River in central California will be the highest head hydro-electric plant in America. The San Joaquin Light and Power Corp., Fresno, Calif., which is building it, expects to have the station in operation within a year.

It is to be named the Balch plant in honor of A. C. Balch, one of the pioneers of the San Joaquin Light & Power Corp. Thus far approximately $1,500,000 and 5 yr. time have been spent in preliminary surveys, in road building and in erecting a power line to supply the construction camps with electricity. The Balch plant is noteworthy not only because of the head at which it will operate, but because ultimately it will contain four of the largest horizontal water-wheel generators in the country. The generator for the first of these units, rated at 33,000 kv.a., 13,200 v. is being made by the General Electric Co.

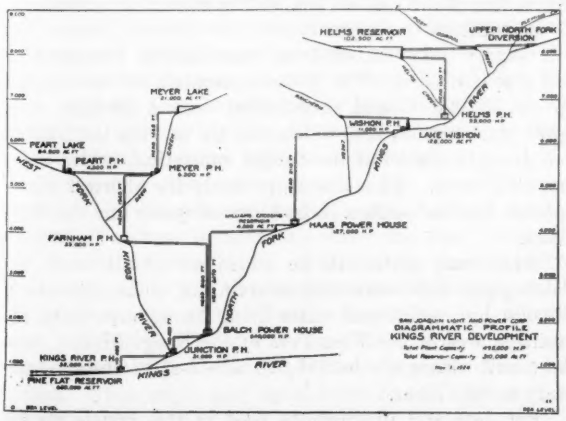


FIG. 1. DIAGRAMMATIC PROFILE OF THE KING'S RIVER DEVELOPMENT, OF WHICH BALCH PLANT IS FIRST UNIT

This plant will be the first step of a 500,000-hp. project on the King's River, as illustrated in Fig. 1, which will involve the expenditure of $50,000,000. The first unit of the Balch plant will have a capacity of 40,000 hp. This unit will have a drainage area tributary to it of 235 sq. mi., which is all above El. 4000, and the greater part is above El. 6000, the upper ridges being over 11,000 ft. and in some spots covered with snow all the year round. The average annual precipitation over this area amounts to about 45 in., and in some years the depth of snow in the meadows is as great as 12 ft. The company maintains eight Government gaging stations over this area for the purpose of obtaining water data. Surveys were started in 1919 in an active manner and after their completion a more or less continuous program on a small scale of road, bridge and camp building has been followed, so that now, at the time of starting the major construction the roads

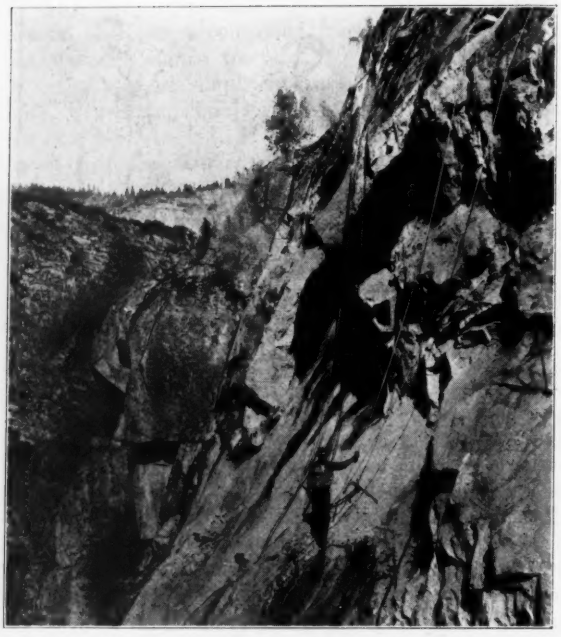


FIG. 2. SOME OF THE DIFFICULTIES OF THE JACKHAMMER MEN ON THE CLIFFS ALONG THE BALCH PLANT ROAD

are about 95 per cent complete and a headquarters camp of permanent buildings has been established, thus making it possible to start this first step on an economical basis.

A dam with a height of 65 ft. and a length of 190 ft. at the crest is now under construction at Williams Crossing, and when completed will form a 200 acre-foot surge pond as in Fig. 4. As the demand for power increases and other power plants are necessitated, it is planned to absorb this dam in a larger dam to be built on the same site. This larger dam will be either a rockfill or a multiple arch structure 175 ft. high, with a crest 800 ft. long. The elevation of the crest of the diversion dam will be 4065 ft., which will provide an initial effective head of 2280 ft. and a static head of 2355 ft. The ultimate structure will raise the elevation of the spillway to 4180 ft., increase the heads to 2312 and 2470 ft., respectively, and create a 5000 acre-foot surge basin. Storage sites farther up in the mountains provide the possibility of further storage developments to the extent of 230,500 acre-feet.

FIG. 3. BIRDSEYE VIEW SHOWING WHERE PENSTOCK RUNS FROM TUNNEL OUTLET TO BALCH PLANT

It is planned to carry the water from the diversion dam at Williams Crossing to the penstock, a distance of over three miles (19,500 ft.), in a tunnel cut through solid granite. This tunnel, 12 by 12 ft., in cross section, will carry 720 second-feet of water at a slope of 3.3 ft. per thousand ft. of length.

Steel penstocks of about 4700 ft. slope length, will connect the tunnel exit at an elevation of 4180 ft., with the nozzles at an elevation of 1710 ft. The abruptness of the descent is evident from these figures and is also shown in Figs. 3 and 4. The upper 3500 ft. of penstock will be a single pipe, while the balance will be split into two pipes because of the pressures encountered. One penstock complete will weigh approximately 1664 t.

At the power house site there is no place immediately at the foot of the penstocks large enough to accommodate the power house, while across the river there is plenty of room. This resulted in incorporating several peculiar features in the plans. The penstocks will be carried across the bed of the stream in heavy, reinforced concrete anchorages, as shown in Fig. 4, and with the water entering the

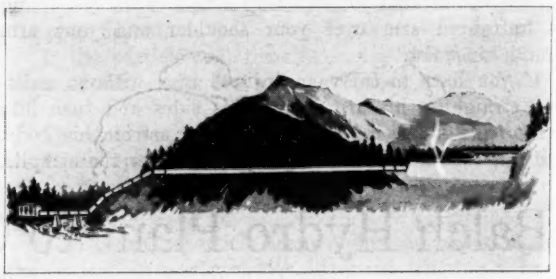


FIG. 4. ARTISTS DRAWING OF PROJECT, SHOWING PRESSURE TUNNEL AND PENSTOCK CROSSING THE RIVER

plant from the river side, the tail race will be constructed in such a way that it will dispose of the water without any back-washing effect. Provision will also be made for preventing undue erosion of the hill-side in back of the plant.

All material will be hauled from the railhead of Piedra over country and private roads, a distance of 30 mi. to the site of the plant and 40 mi. to the site of the dam.

In addition to the generator, the General Electric Co. will supply four 11,000-kv.a. water-cooled transformers and a switchboard. The power generated will be stepped up to 132,000 v. and transmitted over a 39-mile. steel tower transmission line which will tie in with the present San Joaquin system at the Sanger substation, twelve miles east of Fresno. This line is probably the shortest transmission line for such a large block of power on the West Coast.

Additional units will be added and built until the Balch plant will eventually contain six units, developing 240,000 hp., additional water being brought in from the drainage area of the West Fork of the Kings River. Also, there will ultimately be 310,000 acre-feet of storage tributary to this plant.

For data and illustrations used in this article we are indebted to H. K. Fox, Supt. of Construction, San Joaquin Light & Power Corp., to the General Electric Co., and to C. W. Geiger.

Water Power Resources of the United States†

MANY FACTORS DETERMINE HEADS AND STREAM FLOWS THAT MAY BE DEVELOPED AND U. S. G. S. RECORDS GIVE BEST INFORMATION ON POTENTIAL AND DEVELOPED RESOURCES. BY DANIEL W. MEAD*

METHODS of expressing the power resources of the country or the capacity of undeveloped water power sites and of expressing the extent of development on streams where power plants have been installed are so numerous and so different that any figures given are likely to be misunderstood or misinterpreted. To meet this condition, the American Engineering Standards Committee has authorized the U. S. Geological Survey to organize a sectional committee on "Standardization of Units and Bases for Rating the Capacities of Rivers for Producing Water Power," which committee is now considering this subject.

Any dependable estimate of the potential power of a stream must be predicated upon some knowledge as to the head available and stream flow, the two essential elements of water power development. A detailed knowledge of either of these factors is not generally available with any degree of exactness, except where actual surveys have been completed and where stream measurements have been made for a long term of years.

DEVELOPMENT OF HEAD

The head which can be developed is, in general, a function of the fall of the stream and of topography. Its amount is fixed by the difference in elevation between head water and tail water at the proposed power site. But head may be extended beyond the amount developed by the dam, by the use of canals or penstocks which receive the water at the dam and convey it to a site farther downstream than the toe of the dam, where additional fall may be utilized. Head is not constant but varies with the drawdown of the water above the dam and the rise of the tail water during flood flows. The development of head is limited both politically and financially by the location of cities and villages in the valleys or on the flood plains of rivers or of railroads built just above the flood line, and by the existence of valuable farm lands in similar locations where the development of head would create damages greater than the value of the power created.

MANY OBSERVATIONS NEEDED TO DETERMINE STREAM FLOW

Stream flow depends not only upon rainfall, its occurrence and distribution, but also upon area, topography, geology, soil conditions, vegetation, temperature, and the like. In many streams the total annual flow of high flow years is more than double the total annual flow of low flow years, and the highest and lowest flows can be determined only after many years of observation.

The actual value of streamflow for power purposes depends also on pondage and storage. Pondage, or the amount of storage immediately above the dam, is important to impound the excess waters during periods of low power demand so that they may be utilized during periods of high power demand. Where such pondage is not available, the flow can be utilized only as it comes and any surplus above that needed for immediate power demand is wasted. Such waste may equal from 25 to 75 per cent of the streamflow for a day of moderate flow and much more for a day of high flow.

Reservoir systems for the storage of water during longer periods of high flow to be used during periods of low flow are usually practicable only above high heads or in cases where the stored waters may be used in a series of power plants on the same stream. In the latter case,

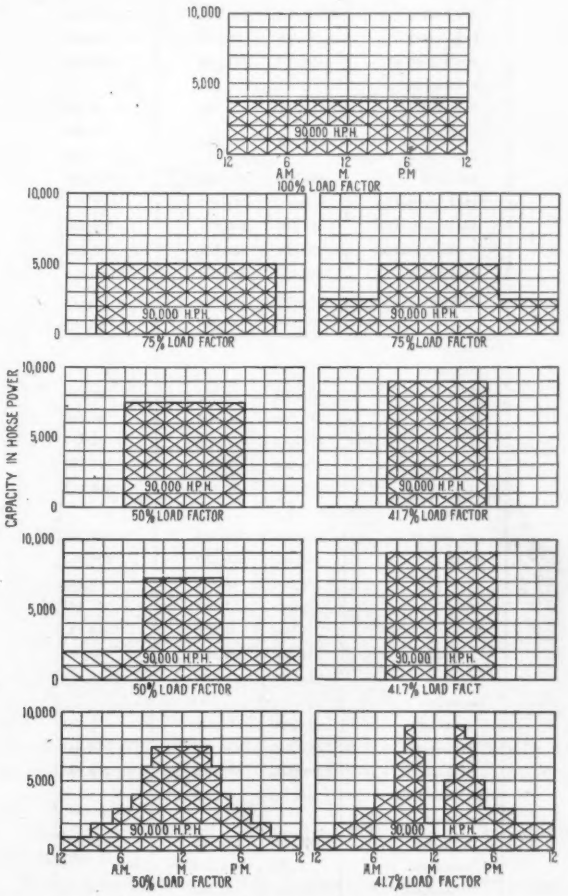


FIG. 1. TO SECURE THE SAME TOTAL OUTPUT, MACHINE EQUIPMENT INCREASES WITH DECREASE IN LOAD FACTOR

stored waters cannot in general be used with the efficiencies that are possible in single high head plants, for the waters frequently reach the downstream plants at times when adequate natural flows are available, hence the water from storage may be wasted. A great saving in the use of stored waters is therefore possible where the plants on a stream are utilized and operated by a single power system or are so co-ordinated that they can be operated with the end in view of both utilizing all of the flow possible at each plant and also using stored water only when no natural flow at any plant in the system is being wasted. The attainment of such ends is one of the important functions of what has been termed super-power development.

In general, water powers, together with any necessary

*Member of Mead & Seastone, Consulting Engineers, Madison, Wis.

†Abstract of paper presented at Midwest Power Conference, Chicago, Ill., Jan. 26 to 29, 1926.

TABLE I. ESTIMATE OF POTENTIAL POWER AND DEVELOPED CAPACITY TO MARCH 1, 1925, COMPILED BY U. S. GEOLOGICAL SURVEY

State	Potential Power Available Horsepower 50% of Time	90% of Time	Developed Horsepower March 1, 1925
Atlantic States			
New England			
Maine	1,074,000	536,000	476,627
New Hampshire	350,000	186,000	243,310
Vermont	169,000	80,000	167,816
Massachusetts	235,000	106,000	344,439
Rhode Island	40,000	25,000	30,188
Connecticut	110,000	65,000	136,423
Middle Atlantic			
New York	4,960,000	4,010,000	1,713,551
New Jersey	90,000	50,000	18,902
Pennsylvania	638,000	257,000	225,996
South Atlantic			
Delaware	10,000	5,000	5,133
Maryland	238,000	106,000	7,230
District of Columbia			666
Virginia	618,000	459,000	117,869
West Virginia	980,000	355,000	14,711
North Carolina	816,000	540,000	534,600
South Carolina	632,000	429,000	507,215
Georgia	958,000	572,000	394,794
Florida	18,000	10,000	9,086
Totals	12,130,000	7,791,000	4,946,556
Central States			
Northeast			
Ohio	166,000	55,000	29,570
Indiana	110,000	40,000	51,276
Illinois	361,000	189,000	86,679
Michigan	274,000	168,000	304,520
Wisconsin	480,000	285,000	412,715
Northwest			
Minnesota	401,000	203,000	252,786
Iowa	395,000	169,000	177,280
Missouri	152,000	67,000	19,970
North Dakota	195,000	82,000	245
South Dakota	110,000	63,000	19,171
Nebraska	342,000	183,000	20,837
Kansas	251,000	104,000	14,464
Southeast			
Kentucky	184,000	77,000	1,256
Tennessee	710,000	432,000	166,347
Alabama	1,050,000	472,000	229,188
Mississippi	60,000	30,000	0
Southwest			
Arkansas	178,000	125,000	15,549
Louisiana	2,000	1,000	0
Oklahoma	194,000	70,000	1,948
Texas	514,000	236,000	13,820
Totals	6,127,000	3,053,000	1,827,621
Western States			
Mountain			
Montana	3,700,000	2,550,000	360,040
Idaho	4,032,000	2,122,000	298,837
Wyoming	1,182,000	704,000	7,886
Colorado	1,570,000	765,000	90,536
New Mexico	186,000	116,000	1,455
Arizona	2,987,000	2,759,000	49,360
Utah	1,586,000	1,420,000	115,329
Nevada	370,000	350,000	13,435
Pacific			
Washington	7,871,000	4,970,000	560,693
Oregon	6,715,000	3,665,000	244,227
California	6,674,000	4,603,000	1,531,480
Totals	36,773,000	23,974,000	3,273,478
Totals in U.S.	55,030,000	34,818,000	10,047,655

auxiliary power, should be developed only when their combined capacity and output of energy is furnished at less cost than from any other source. Capacity can sometimes be obtained from a water power plant at less cost per horsepower than from a steam plant. In this case pondage is essential.

The quantity of power produced by stream flow under the head developed depends upon the machine equipment as well as on the pondage or storage. If the load is constant and uniform from hour to hour and from day to day in other words, if the load factor for the plant is 100 per cent, no pondage is necessary except for emergency use, and the machine equipment can be limited to the economic capacity of the development. In proportion as the load factor on the plant decreases, the machine equipment must be increased in order to secure the same total output of energy, as shown in Fig. 1. When a plant is independently operated and must take care of all changes in load, each 1000 hp. of machine installation will produce 24,000 hp. of energy with a 100 per cent load factor; but the same output will require 2000-hp. equipment with a 50 per cent load factor, and 3000-hp. equipment for a 33⅓ per cent load factor. The ability of these larger machine installations to produce this output is dependent also upon the available pondage.

Approximate Estimates of Power

Bearing the above discussion in mind, the amounts of water power already developed and still available for development may be approximately estimated.

In the absence of a standard rating and for present purposes, the power capacity of streams may be stated in terms of theoretical horsepower available for 50 and 90 per cent of the time, these percentages being based on the average streamflow and the total head available for the rivers considered. From these averages of flow, in extreme cases the maximum average annual flow may be more than double the long-time average, and the minimum average annual flow may be from one-half to even one-quarter of the long-time average flow. Evidently, it is difficult to express in any tabular form any comprehensive statement of either the developed or undeveloped water powers of a river.

U. S. G. S. Has Issued Information on Developed and Undeveloped Resources

The writer knows of no better source of information concerning the developed and undeveloped water power resources of the United States than the estimates made, from time to time, by the U. S. Geological Survey. These estimates have therefore been used as a basis of the following tables. Unless the basis of calculating these water power resources is understood, these estimates are likely to be misleading.

The first estimate of the national water power resources was contained in the report of the U. S. Geological Survey to the National Conservation Commission in 1908. This estimate was based on the fall and flow of the streams of the United States, omitting the low slopes and without regard to the practicability of development. Later estimates have been based on somewhat more satisfactory data, but they still mean very little in terms of present feasibility.

The U. S. Geological Survey statement of developed powers is expressed in terms of horsepower of hydraulic turbine capacity. This gives but little idea of the actual

power of water available except for peak loads, and even this is uncertain unless storage or pondage is known to be available. For a clear idea of actual water power available from existing installations, there should be given the average available power for 50 and 90 per cent of the time on the developed streams, and a similar statement for those streams not yet developed. For example, the U. S. Geological Survey estimate shows that Massachusetts has an average of only 235,000 potential horsepower for 50 per cent of the time and has developed turbine capacity of 344,439 hp. This leaves it uncertain whether the total potential hydraulic power of Massachusetts has been developed, and if not, it would seem that the undeveloped potential power should be stated.

In estimating the potential water powers of the United States, the practicability of the immediate development of the powers cannot be considered, for if it were considered, there would at once be eliminated a large percentage of all the undeveloped powers of the United States which cannot be developed at the present time on account of one or more of the following reasons: 1, lack of a market within practicable transmission distance; 2, excessive expense of development; 3, legal restrictions and entanglements.

TABLE II. INSTALLATIONS IN 17 STATES, EACH OF OVER 200,000 HP. ON MARCH 1, 1925, WITH AN ESTIMATE OF HORSEPOWER INSTALLED DURING 1924

State	Hp. Capacity March 1, 1925	Increase Since January 1, 1924
New York	1,713,551	170,568
California	1,531,480	79,650
Washington	560,693	80,337
North Carolina	534,600	103,100
South Carolina	507,215	149,705
Maine	476,627	3,439
Wisconsin	412,715	8,433
Georgia	394,794	30,400
Montana	360,040	15,000
Massachusetts	344,439	500
Michigan	304,520	22,902
Idaho	298,837	27,919
Minnesota	262,786	50,936
Oregon	244,227	37,562
New Hampshire	243,310	7,500
Alabama	229,188	13,325
Pennsylvania	225,996	56,000
Total for 17 states	8,645,018	857,076
Total for United States	10,047,655	960,697
Percentage in 17 states	86.1%	89.2%

It is evident, therefore, that estimates of total undevoloped powers will include power which ultimately may be developed if conditions ever arise that will make such developments practicable. Just how far the potential water power developments have been included by the United States Geological Survey is uncertain.

An adequate estimate of water power on any stream or at any point on a stream which can be utilized can be made only after:

1. A considerable series of annual streamflow measurements have been made, and these have been extended by a careful study of the longer periods of climatic and rainfall observations, and duration curves for the stream flow for the high, low, and average year established as nearly as possible.
2. A detailed topographical survey has been made of the stream or sections of streams to be developed, and
3. A study has been made of the needs and probable capacity of the prospective power market.
4. Plans for construction have been developed in accordance with the physical, hydrographic and market conditions determined by 1, 2 and 3.

NO.	COMPANY	K.W.	NO.	COMPANY	KW.
1	COMMONWEALTH POWER CORP.	101,500	15	ALPENA POWER CO.	1,200
2	PENINSULAR POWER CO.	17,850	16	SOUTHERN WISCONSIN POWER CO.	8,000
3	WISCONSIN PUBLIC SERVICE CORP.	33,250	17	WISCONSIN RIVER POWER CO.	30,500
4	NORTHERN STATES POWER CO.	104,000	18	WISCONSIN POWER AND LIGHT CO.	43,000
5	WISCONSIN VALLEY ELECTRIC CO.	12,800	19	MISSISSIPPI RIVER POWER CO.	135,000
6	INDIANA HYDRO-ELECTRIC	15,000	20	FORD MOTOR CO.	5,000
7	INDIANA AND MICHIGAN ELECTRIC	17,500	21	UTILITIES POWER AND LIGHT CORP.	1,750
8	DETROIT EDISON CO.	4,775	22	CHIPPEWA POWER CO.	20,000
9	MICHIGAN GAS AND ELECTRIC CO.		23	WISCONSIN POWER LT. HT. AND TR. CO.	1,810
10	PUBLIC SERVICE CO. OF NORTHERN ILLINOIS		24	MISSISSIPPI VALLEY PUBLIC SERVICE CO.	5,000
11	MICHIGAN NORTHERN POWER CO.	23,600	25	CEDAR VALLEY ELECTRIC CO.	720
12	CENT. NORTHERN POWER CO.	48,000	26	SANITARY DISTRICT OF CHICAGO	15,000
13	NORTHERN ILLINOIS LIGHT & TRACTION CO.	3,000	27	ILLINOIS NORTHERN UTILITIES CO.	3,200
14	LAKE SUPERIOR DISTRICT POWER CO.	3,000			

FIG. 2. APPROXIMATE SIZE, LOCATION AND OWNERSHIP OF HYDRO-ELECTRIC DEVELOPMENTS IN NORTH CENTRAL STATES

Any more limited knowledge will lead to erroneous conclusions.

Table I shows the United States Geological Survey estimate of total potential horsepower of the various states in the nation on the basis of their availability for 50 and 90 per cent of the average year, together with an estimate of the capacity of turbines installed.

Table II shows the installation of turbines in the seventeen states having each over 200,000 hp. installed on March 1, 1925, with an estimate of the horsepower installed in each of these states during 1924. These seventeen states contain over 86 per cent of the total turbine capacity installed on March 1, 1925, and show an increase of over 89 per cent of the turbine capacity installed in the United States between January 1, 1924, and March 1, 1925. Again it should be noted that the figures are only approximate; for example, the office of Mead and Seastone installed in Wisconsin during 1924, 14,550 hp. in turbine capacity or about 172 per cent of the increase credited to Wisconsin in Table II.

Figure 2 shows the approximate location and ownership of most of the principal hydro-electric developments in the North Central States adjacent to Chicago, with an extremely general estimate of the installed capacity in kilowatts.

PRESENT RATE OF DEVELOPMENT LIKELY TO CONTINUE

It is likely that approximately the present rate of development may continue for some years in the future, because the extension of transmission lines and the combining of the smaller electric power companies, or their absorption by the larger companies, are making feasible for development some power sites that have been hitherto unavailable. The writer does not anticipate any great acceleration in the rate of development in the future inasmuch as in most cases the undeveloped powers available each year are farther from the market or are more expensive to develop. Then too, the necessity of more thorough and complete investigation, and of more care in planning, is becoming more evident.

As the powers of the Atlantic and Central States are developed, there will doubtless result a slowing down in the rate of development, for it will scarcely be possible that the Western States—where the larger proportion of the available powers is located—will increase in population and in demand for power with sufficient rapidity to justify the continuation of the present rate of development.

It will be noted from what has been stated above that there is little exact information available to the public concerning the amount of potential water power in the United States and still less concerning the amount of water power that is or will be commercially available in the near future. President Coolidge in his message to Congress of December 8, 1925, says, "We should constantly engage in scientific studies of our future requirements and adopt an orderly program for this service."

In line with this principle, and recognizing the need for a greater and more exact knowledge of the water resources of the country, a bill has been introduced into the House of Representatives (H.R. 6358) "To provide for an inventory of the country's water resources." This bill has been approved by the American Engineering Council, and instructs "the Director of the Geological Survey under the Secretary of the Interior to make, within a period of twenty years, an inventory of the water resources of the United States, including data that will be required in making a comprehensive plan for developing both surface and ground water for domestic and industrial supplies, irrigation, navigation, power, and other uses, and for conservation and control of flood waters."

For many years the Survey has carried on the gaging of some of the streams of the United States and has made surveys of some of the streams, but the work has been done with limited appropriations which have permitted an investigation of only a small part of the nation's resources. This work seems of general importance not only to those interested in water power but also to many others interested in water resources for many other purposes; and the passage of the bill can well be encouraged by all interested in the water resources of the nation.

Impeller Chart for Centrifugal Pumps

DERIVATION OF CHART OF VELOCITY RELATIONS BY CHARLES FROMM*

DESIGNING and estimating engineers of centrifugal pumps should find the accompanying chart a decided help, as it shows in a brief and time-saving way some useful conclusions as to the relations between the diameter or size of an impeller, the speed or revolutions per minute and the possible total head against which this impeller is able to deliver a certain capacity of a fluid in a suitable case.

In this place it may be said that the chart is not intended to replace theories on centrifugal pumps, since there are so many and different ones, especially after the application of the theory of circulation has affected the design of centrifugal pumps and their impellers in the most advantageous manner.

The chart should also be a help to those who are not familiar with the various theories and their applications and who are not experienced centrifugal pump engineers.

The theoretical value of the total head in feet against which the centrifugal pump will deliver the fluid can be expressed by the formula:

$$1.\quad H_{th} = \frac{1}{g}\,(u_2\ C_{u_2} - u_1\ C_{u_1})$$

In which

$g = 32.16$ feet per second per second = acceleration by gravity.

u_2 in feet per second = the circumference velocity of the impeller at its exit

C_{u_2} in feet per second = the component of the absolute exit velocity C_2 upon u_2

u_1 and C_{u_1} are corresponding figures for the entrance of the impeller

Assuming that the entrance in the impeller is radial, formula 1 becomes

$$2.\quad H_{th} = \frac{1}{g}\,u_2\ C_{u_2}$$

If N_h is the hydraulic efficiency of the pump, the total head will be

$$3.\quad H_t = N_h \frac{1}{g}\,u_2\ C_{u_2}$$

C_{u_2} will be a certain ratio, R, of u_2. The total head can now be written $H_t = N_h \frac{1}{g}\,R\,u_2^2$ or introducing the velocity head

$$4.\quad H_t = K\,\frac{u_2^2}{2g}$$

It will be seen from this formula that we are able to figure the approximate head of a centrifugal pump, if we know the circumference velocity u_2 which is determined by the diameter of the impeller and the revolutions per minute and the coefficient K, which can be found from actual tests of similar pumps with similar impellers.

The chart is based upon the formulas:

*Mechanical Engineer, Aldrich Pump Co., Allentown, Pa.

5. $u_2 = \dfrac{D \times R.P.M.}{229}$ feet per second (D = diameter in inches)

6. $\dfrac{u_2^2}{2g} = \dfrac{(D \times R.P.M.)^2}{3.374 \times 10^6}$

Scale No. I shows the diameter; Scale No. II shows the r.p.m. and on the right side the usual motor speeds; Scale No. III shows on the left side the circumference velocity and on the right side the velocity head.

A straight line from Scale No. I to Scale No. II cuts Scale No. III at the corresponding circumference velocity and velocity head. The coefficient K varies mostly from 0.90 to 0.75, and depends upon the form of the characteristic curve. For a steep curve, the coefficient is usually smaller than for a flat one.

In the same way we can write for the shutoff head

$$H_{sh} = K_s \frac{u^2}{2g}$$

This coefficient K_s varies usually from 1.00 to 1.15, according to the different character of the characteristic curves.

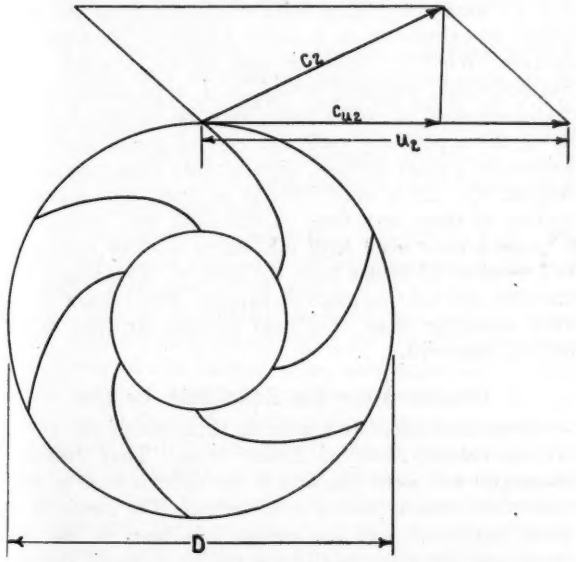


FIG. 1. DIAGRAM OF RELATIVE VELOCITIES OF IMPELLER AND LIQUID HANDLED BY CENTRIFUGAL PUMP

Figure 2 shows a characteristic curve of a 4-in. double suction volute pump, the speed of which is 1750 r.p.m., diameter of impeller 10⅞ in., the efficiency at 800 gal. per minute being 78 per cent at a head of 96 ft., the shutoff pressure amounts to 119 ft. and the velocity head is 107 ft.

For this example the coefficients are K = 0.90 and K_s = 1.11. From the chart we can as readily obtain the approximate size of the impeller if head and speed are given.

Example 1:

If the diameter of an impeller is 16 in., what will be the total head and the shutoff head at 1150 r.p.m.?

Answer:

A straight line from 16 on Scale I to 1150 on Scale II cuts Scale III at the circumference velocity u_2 = 80.5 ft. per sec. and the velocity head $\dfrac{u_2^2}{2g}$ = 100 ft. Assuming K = 0.90, multiply 100 by 0.90 or take off 10 per cent, the total head will be 90 ft. Assuming K_s = 1.1, multiply 100 by 1.1 or add 10 per cent, the shutoff head will be 110 ft.

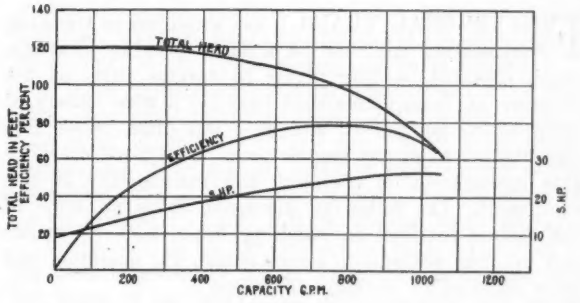


FIG. 2. CHARACTERISTIC CURVES OF A 4-IN. DOUBLE SUCTION VOLUTE CENTRIFUGAL PUMP

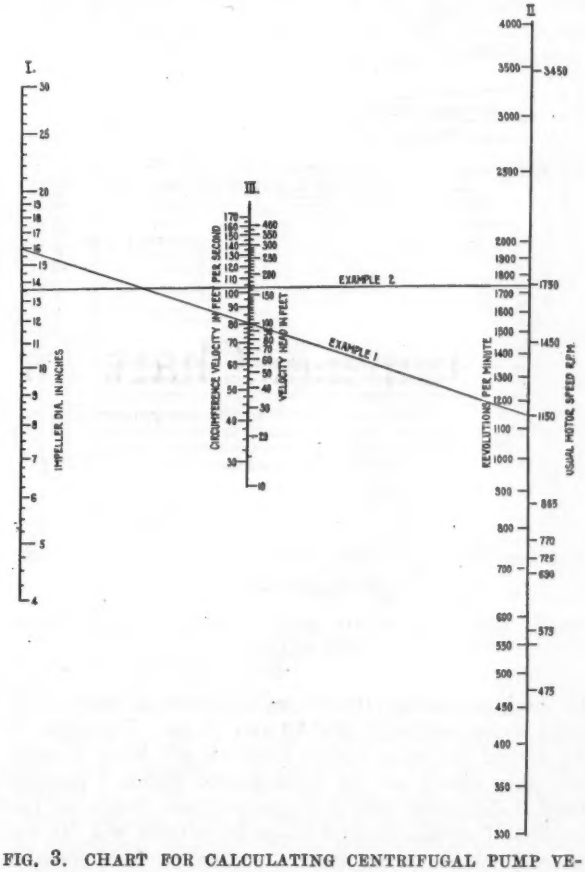


FIG. 3. CHART FOR CALCULATING CENTRIFUGAL PUMP VELOCITY RELATIONS

Example 2:

If the total head of a pump is to be 150 ft. at 1750 r.p.m., what will be the approximate diameter of the impeller and what will be the shutoff head?

Answer:

Assuming K = 0.90, the velocity head will be $\dfrac{150}{0.90}$ = 167 ft.

A straight line from 1750 on Scale II to 167 on Scale III cuts Scale I at the required impeller diameter of 13.6 in.

Assuming K_s = 1.1, the shutoff head will be 1.1 × 167 = 184 ft.

Handling Brine in Coolers and Spray Systems

OPERATION OF COOLERS FOR BOTH SALT AND CALCIUM BRINE, LAYOUT OF BRINE SPRAY SYSTEMS AND DESIGN OF BRINE EVAPORATOR ARE DISCUSSED. BY J. F. STALEY

FOR SEVERAL YEARS I was employed as traveling refrigerating engineer by a large packing company, which operated packing plants in various parts of the country. In these plants were installed a wide variety of refrigerating equipment, and as I was often called into consultation when any trouble arose, I acquired considerable information on operation and maintenance of this equipment. The following discussion takes up some of the factors involved in handling brine, both in coolers and in spray systems, to secure economical operation and more satisfactory working conditions.

At one time I was sent to find the cause of high temperatures in the cold storage rooms of one of our plants.

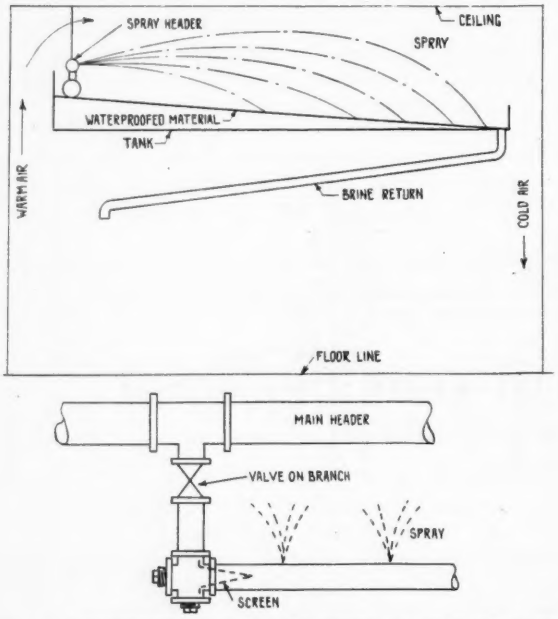


FIG. 1. CONSTRUCTION OF BRINE DECKS AS USED IN PACKING PLANTS

In the brine cooling room were 13 stands of double pipe brine coolers, although only 10 were in use. The night of my arrival the brine coolers froze up and when I asked why they didn't use the three unused stands I had noticed, I discovered that they also had been frozen for two months. I at once realized where the trouble was. It was no easy task to repair these 3 coolers, as there were 22 split pipes and a number of broken bends, but it was finally done.

Next came the task of removing the brine that had been driven into ammonia system; the oil traps were full of brine and some had gotten into the ammonia condenser. I soon had the ammonia cleared up and 3 coolers back at work. The other 10 were a little more difficult, as in all there were 66 pipes split in these and 42 bends and 70 glands broken. To overcome troubles like this, I always recommended a pressure gage that would ring a bell alarm as soon as brine pressure raised or lowered 10 lb. from the usual pressure carried.

Another plant which had frozen its three shell-type brine coolers, was supposed to use calcium brine in these coolers, so there was a large amount of calcium used. The management had complained to the chief about this, so he had begun to use part salt instead of calcium, so that he could keep down these complaints. (How many engineers realize that when mixing salt with calcium brine the freezing point is raised considerably and the danger is much greater than if salt brine or calcium brine are used separately?) Well, he practically had to retube these shell coolers. Then he built a large regenerator to purify the ammonia in the system. In addition, the calcium that had been drawn into the machines was baked on the valves so they would not work at all and the piston rings were stuck solidly into the slots in the piston.

After getting these in shape, our next trouble was in our ammonia condensers. Our head pressure stood at 230 lb., the machines running slow. The condensers were of the atmospheric type, 30 pipes high. It was evident that we were not getting sufficient liquid from our condensers to operate on, so I placed a gage on the ammonia receiver. When it registered only 50 lb., I knew there was something seriously wrong, so I went along feeling the condensers, of which there were 80 stands. I found 23 of them perfectly cold and several others that were warm only a short distance, showing that these were partly stopped up. All I could do was to pump out a certain portion of these at a time. Taking out the liquid lines, I found several filled with calcium as solid as it is when it is received in drums from the factory. Yet, I have had chemists tell me this couldn't happen. But I knew it did after repairing these. The head pressure dropped to 180 and all was well.

COOLERS MUST BE KEPT FREE OF OIL

I was once called to a packing plant which was having trouble cooling down its freezer brine. They desired a temperature of —10 deg. and it was difficult even to reach zero when running with a 5-in. vacuum. The owner of the plant explained that the coolers had been in use only 3 yr. and that each year it was harder to reach the temperature desired. On investigation, I found that these coolers on the fourth floor of a room carried a temperature of +30 deg. These coolers were covered with ice 18 in. thick.

I asked the owner when he had drawn the oil out of the two coolers. He said he never knew there was oil in them. I explained to him that no doubt considerable oil had collected in them in three years' time and that the best thing to do was to shut one cooler off at a time and warm it up.

So a steam siphon was connected to the bottom of the cooler discharging it in top. After heating the cooler to +40 deg., we drew out 2 bbl. of oil with a small portion of water. When I wanted to cover these coolers, the owner objected, saying that they helped to cool that room. I explained to him that his house brine, which was carried at a temperature of 12 to 14, was cooled at a much lower cost per ton than was the freezer brine, so then he consented to have these covered, after cleaning the other cooler, which contained almost the same amount of oil.

There was then no difficulty in getting the brine to the desired temperature.

Many engineers are under the impression that oil can be drawn out of brine coolers or expansion coils carried at zero or below while they are in use. This is incorrect and it is well worth the time needed to allow these to warm up and remove the oil by blowing out, as oil is an insulator and losses amounting to from 10 to 40 per cent are common occurrences from this item alone.

Faulty Compressor Piston Lowers Capacity

At one of our plants the power costs were unusually high and I was sent there to check them. Of course, I started in the boiler house. I found the water being fed to boilers at a temperature of 170 deg. and 3 lb. exhaust pressure carried on exhaust lines. I found many steam leaks and uncovered steam lines. The plant was equipped with chain-grate stokers using mine run coal, which was dumped into the boiler room direct from the mine. Boilers were in fair condition, as were the stokers, although the boilers were set too low for good combustion.

In the engine room were two direct-connected ammonia compressors; one was a double-acting machine, the other a single-acting.

As the management had given me orders not to spend any money, only to make recommendations on what was needed, I began by taking indicator cards off all the steam engines. The valves did not need much adjustment. On indicating the single-acting compressor I found that one cylinder had a large amount of clearance, which also was easily taken care of.

The double-acting compressor was not so easy. The crank end gave a good card but on the head end the card showed a great amount of clearance or a leaky discharge valve. But on measuring clearance and testing valves, these were found to be all right. So I pulled the piston, which was of the built-up type, and examined it before I took it apart. The bull ring was loose; that is, it could be turned on the spider of the piston without any exertion; I removed the nut and there I found the trouble. The bull ring was a little short, not allowing the end of the piston to make a fit, so, when the piston traveled towards the head end, the ammonia gas would get into the hollow spider, and when the machine started on reverse stroke, this gas would leak out. I had a thin steel washer made, the same diameter as the bull ring. On replacing the piston and the head and starting the compressor, I was able to get good cards of each end. This machine was losing 1/10 of its capacity from this one fault alone and the above experience shows one reason an ammonia compressor should be indicated occasionally.

Details of a Brine Spray System

In the modern packing plant, we find the brine spray system a necessity. Two systems are in general use, the deck spray system and the wall spray system. Decks are already installed in most packing plants and it is usually an easy matter to install the sprays.

The best method of laying out piping for brine decks will be shown, as well as for wall sprays. It is much cheaper to weld nipples into pipe than to use tees, thus doing away with several joints that are liable to cause leaks in time. Then, too, most of this work can be done in the shop and the remainder in the brine deck.

Sprays are usually spaced 6 ft. apart. In brine decks, the feeder lines for sprays are usually from 1½ in. up to 3-in. pipe, according to the number of sprays. It is well not to place over 10 sprays on each branch. These are controlled by one gate valve strainer to be placed as shown. As small particles of sawdust and strings often find their way into the brine, the sprays are often stopped up if they are not provided with a suitable strainer.

Figure 1 shows the general arrangement of a brine deck. The brine header is shown at B, showing location with spray canopy on cold air side, which is for protection in case brine pressure becomes great enough so that brine goes over to the product below. These canopies are generally built of ⅞-in. lumber, covered with two layers of tar paper laid in hot insulating pitch. The floor of the deck is generally laid of ⅞-in. lumber covered with five layers of tar paper, well lapped on cold and hot air duct. These layers should all be laid in hot pitch, so that each seam will overlap the previous seam. The drain pipe should be hung just below the brine deck, which should have sufficient fall to drain into the brine tank. A 4-in. lead pipe nipple, with a flange turned on end of

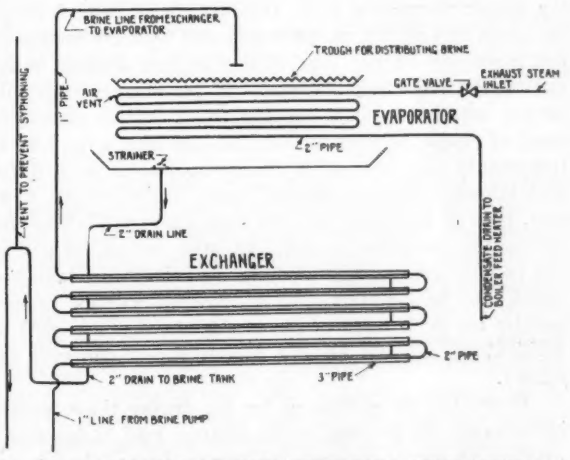


FIG. 2. EVAPORATOR OF THIS TYPE WILL KEEP BRINE AT THE REQUIRED STRENGTH

one continuous piece of lead pipe, should reach at least 4 in. into the brine drain.

Evaporator Maintains Brine Strength

Where the spray system of brine circulation is used, the brine condenses the moisture in the air, causing a surplus of brine and at the same time weakening it. Where calcium brine is used, this is costly, and, too, it is dangerous, especially where brine coolers of the shell or double pipe type are used, for when the brine weakens, a frozen brine cooler is the result.

To prevent these troubles, an evaporator can be built on the engine room roof or where there is plenty of air to carry away the waste heat. The evaporator, shown in Fig. 2, should be built of 2-in. pipe with 5 or 6 in. between center lines. Coils should be not over 10 ft. long and 6 pipes high, the number of stands to be determined by the size of plant. A metal pan should be placed under coils and a saw tooth trough or a slotted pipe trough should be placed over the coils for distribution of brine.

Exhaust steam should be connected to the top pipe of the coil at one end, as shown, and a small vent should be placed in top bend of other end. Drains from the coil

are returned to the boiler feed heater; brine for the evaporator comes from the discharge of the brine pump, before the brine is cooled, or direct from the return line in the house. A double pipe heat exchanger is placed between the pump and the evaporator at a point high enough so brine can flow by gravity back to brine tank. This heat exchanger is often built of 2 and 3-in. pipe, using the 2-in. pipe for the cold brine going to evaporator, and the 3-in. pipe for warm brine coming from evaporator. Care must be taken to see that lines are run so as to hold the 3-in. pipe full of brine at all times for best results. The heat exchanger for a one coil evaporator should be 6 pipes high and 18 ft. long.

By using this system, only a small amount of heat is used and there is little loss in temperature of brine. An evaporator of this size used only 8 hr. each week will keep brine at the correct density for a plant pumping 1500 g.p.m. of brine for use in a spray system.

Control of Evening Peak Load of Ice Plants*

Calculations Show How a Motor-Driven Plant Determined Most Economical Peak Under Prevailing Central Station Rates and Penalties. By Charles H. Herter.

IN VIEW OF the fact that motor-driven ice and refrigerating plants enable central power stations to utilize their generating equipment at times when their industrial or lighting load is low and as these plants, moreover, represent a continuous load free from great fluctuations, the power companies concede to such users a special rate, if it is agreed to use, in New York City, for example during the winter months of Nov., Dec., Jan. and Feb., between the hours of 4 to 8 p. m. (Sundays and holidays excluded) not exceeding 20 per cent of the highest demand made during the preceding summer. If for some reason this 20 per cent is exceeded, the additional current consumed must of course be paid for, and besides this, a penalty is imposed in the form of a charge equivalent to $10 for each kilowatt of excess demand made. This penalty, however, need be paid only the first time the excess is recorded during the particular winter. In other words, by paying the penalty once, a new evening peak load is established which may be maintained or approached without further penalty for the balance of the winter months (except if by accident or carelessness still higher excess demands are made).

Where the daily demand for ice during these months exceeds, say, 35 per cent of the summer load, it becomes a problem to decide whether the power demand had better be cut down to the prescribed 20 per cent, or whether, in view of more business done, it would be advantageous to pay a penalty up to a certain amount.

The writer knows of an ice plant equipped with two 230-t. and two 60-t. ice making machines, total 580 t. ice per day in summer. One winter, to escape paying any penalty, the manager decided to run in the evening one small compressor only and, during the other hours, to run one side of a large duplex machine. The result was that the brine temperature went up too high during the evening, and the output was declared insufficient.

Actual Performance of Plant in Winter

During the present winter, 1925-26, it was decided to keep one of the four 19-in. cylinders running in the evening and to reinforce this during the remaining 20 hr. with either one or two of the 15-in. cylinders, thus producing either 220 or 280 t. of ice per day as might be required. To keep the evening power consumption down to a minimum, no cans of water are lowered into freezing tanks during this time; the motors on the 28 brine agitators, cranes and hoists are stopped; only one condenser water pump is left in service; the water cooling tower is shut down to an amount depending on atmospheric temperature and last, but not least, the flow of ammonia to the ice tank coils is diminished. For example, during the seven days starting Dec. 10, 1925, one 19-in. cylinder was used exclusively, and the average daily production was 224.5 tons. (The daily average for Dec., 1925, and Jan., 1926, was 221.5 t.) Total current consumed in plant in that week was 37.7 kw.hr. per ton of ice. Cooling tower water was used, ranging in temperature from 42 to 48.25 deg. F. Condenser pressure, evenings 82 lb.; during the 20 hr., 87 lb. gage. Ammonia suction pressure, evenings, 20 lb.; during 20 hr., 25 lb. Average brine temperature, 4 hr., 20.3 deg.; 20 hr., 21.4 deg. To be sure of reducing the power in due time, the expansion valves on the freezing tanks are throttled several minutes before 4 p. m., and opened after 8 p. m., so that the evening period actually occupies about 4¼ hr., as evidenced on pressure recording charts.

While it is true that the power per ton consumed by a compressor increases as the evaporator temperature is lowered, the total power required by the compressor falls off, and its capacity decreases also. Under the conditions stated it is not at all self evident as to which course is the most advantageous one.

In attempting a solution, which will necessarily apply to local conditions only, we may estimate the relative cost per ton of ice made during the 4 mo. with and without penalty. From Nov. 1, 1925, to Feb. 27, 1926, includes 17 power weeks or 119 days. On the 17 Sundays plus 4 holidays no restriction is made as to demand for current.

Comparing Performance With Calculation

In the above ice plant the net piston displacement of one 19 by 19-in. double-acting compressor at 164 r.p.m., with a 3-11/16-in. piston rod, equals 1003.3 cu. ft. per min.

Ratio of absolute pressures, day time: $\frac{87 + 14.7}{25 + 14.7} =$ 2.56 : 1. Volumetric efficiency with 4 per cent average clearance volume = 0.95. Assume real volumetric efficiency equal to $0.95 \times 0.95 = 0.9025$; hence vapor circulated per min. equals $1003.3 \times 0.9025 = 905$ cu. ft.

Refrigerating effect per lb. equals: Latent heat at 25 lb. or 560 B.t.u., less the difference in heat content of liquid at 57 and 11 deg. (105.8—55) or 50.8 B.t.u, leaves 509.2 B.t.u. available for useful work.

Volume of saturated vapor at 25 lb.=7.1 cu. ft. per lb. Hence, $905 \div 7.1 = 127.5$ lb. of vapor circulated at 509.2 B.t.u. per lb. This equals 64,900 B.t.u., which, divided by 200 equals 324.5 t. of refrigerating effect. This

*Discussion presented at February, 1926 meeting of N. Y. Chapter No. 2 N. A. P. R. E.

amount, divided by 1.4 (winter condition) equals 232 t. of ice per 24 hr., or times 19.75/24 = 186 t. ice per 19.75 hr.

Calculating in the same way the performance during the evening, we have: Ratio of absolute pressures, $\frac{82+14.7}{20+14.7}$ = 2.788 : 1. Apparent vol. effic. with 4 per cent clearance = 0.9275, and the real efficiency, 0.9275 × 0.95 = 0.881. Hence vapor circulated per min. equals 1003.3 × 0.881 = 883.5 cu. ft. Refrig. effect per lb. equals: 565 —(103—48.5) = 510.5 B.t.u. Volume of saturated vapor at 20 lb. = 8.06 cu ft. per lb., therefore, 883.5 ÷ 8.06 = 109.6 lb. vapor circulated at 510.5, or a total of 56,000 B.t.u., which, divided by 200, equals 280 t. of refrigerating effect. Dividing again by 1.4, we obtain 200 t. ice making capacity per 24 hr., or, times 4.25/24 = 35.42 t. ice per 4¼ hr.

Thus the total ice production becomes 186 + 35.42 = 221.42 t. per 24 hr., while, with no extra throttling of ammonia, the output would have reached 232 t., under the conditions stated. At a higher back pressure than 25 lb., the production would be greater still, because the can capacity in use is 7 × 900 or 6300 (300-lb. blocks) but few engineers can be induced to carry their back pressure high enough.

On the basis of the week analyzed, and throttling the valves in the evenings, the total production during the 17 power weeks figures out as follows:

98 days at 221.42	=	21,700 t.
21 days at 232	=	4,870 t.
Total,		26,570 t.

At 37.7 kw-hr. per ton, the total becomes 1,001,689 kw.-hr., which at 1.1 cents equals $11,018.58, or a total power cost of 41.5 cents per t.

Penalty Incurred

In this instance, the winter evening peak demand should not have exceeded 316.8 kw., therefore a penalty of $512 had to be paid after the first week in November because the evening demand had been allowed to exceed this amount 51.2 kw. The above cost of 41.5 cents per ton of ice is therefore to be increased. On the other hand, having once paid a penalty, the plant is privileged to boost its winter production up to 280 t. per day, if desired; in fact, the average for Nov., 1925, was 264.25 t. The above estimate is therefore to be corrected as follows:

November, 28 days (4 weeks) at 264.25 t.	=	7,399 t. of ice.
Remainder of winter, 74 work-days at 221.42	=	16,385 t. of ice.
17 holidays at 232	=	3,944 t. of ice.
Total winter production,		27,728 t. of ice.

At a more conservative average of 40 kw-hr. per ton, the consumption aggregates 1,109,120 kw-hr., which at 1.1 cents equals $12,200.32, equivalent to 44 cents per ton. The addition of a $512 penalty increases the bill to $12,712.32, equivalent to a real power cost of 45.8 cents per ton.

If the expansion valves were not throttled, the evening peak might rise to 400 kw., resulting in an additional penalty of 400 — 368 or 32 kw. at $10 = $320, while the production during 74 days would be or could be increased by 232 — 221.42 or 10.58 t., total 782.92 t. At $2 per ton the profit would be $1,565.84. After deducting the $320, the gain is still $1,245.84, showing once more that the penalty need not be feared so much as is commonly done.

Loss with Low Evaporator Pressure

Whenever refrigeration is being performed at a lower evaporator temperature than is absolutely necessary, a loss is incurred which must be paid for. If, by throttling the feed valves, the suction pressure is lowered 5 lb. below 25 lb. gage, the ice production of the machine in question is not only reduced from 232 to 200 t. per 24 hr. (a loss of 13.8 per cent) but the power consumed per ton of ice is increased 5 per cent. For example, at 232 t. ice the brake horsepower is 232 × 1.091 or 254 hp., while at 200 t. it is 200 × 1.19 or 238 b.hp. With 20-lb. suction pressure, the increase in power demanded by compressor is 2 kw-hr., which at 1.1 cents equals an additional cost of 2.2 cents per ton of ice.

The conclusion is reached that in any case the probable production should be approximated at the outset, likewise the cost of power, and a calculation made to determine the effect a penalty would have on the cost per ton of winter ice. Lowering of suction pressure is not advised. A steady economical rate of production should be maintained and large fluctuations eliminated.

Capacity Reducers Are Indispensable

In this connection, it is proper to point out the great advantage derived from capacity reducing devices, such as clearance pockets, which permit unloading a compressor without lowering the suction pressure. No motor driven ammonia compressor is complete if it is not equipped with a capacity reducer. Manufacturers ought to be progressive enough thus to equip their machines regularly without waiting to be compelled by consulting engineers to do so. This is particularly true where a cooling tower must be used, because on extremely cold days the tower can be used only partly or not at all for fear of ice accumulation, the weight of which is likely to damage the tower seriously. On such days the condenser pressure will rise, demanding extra power. If, then, the clearance pockets are opened, the load can be held to the desired figure without sacrificing economy. Also on hot or muggy days in summer, when the tower is at a disadvantage and the power demand rises to high peaks, the clearance pockets save the situation. Hence they invariably pay for themselves within one year.

The sale of incandescent lamps such as are used in the lighting of homes reached the total of 280,000,000 in 1925, according to an annual review of the electrical industry by John Liston of the General Electric Co. This is an increase of 7¼ per cent over 1924, and 4½ times the figure for 1908. In addition, the sale of miniature lamps, such as are used in automobiles, flashlights, on Christmas trees, etc., reached the total of 195,000,000, an increase of about 3½ per cent over 1924. "Although the average wattage of lamps has varied but slightly, the average lumens or candlepower has increased considerably," Mr. Liston points out. "The price of lamps has been reduced materially in recent years, due to improved methods in manufacture."

Never use hard packing in centrifugal pump packing glands.

Things Sometimes Go Wrong

HERE ARE SOME OF THE REASONS. BY W. H. MOORE

THINKING of "dumb-bell stunts" that I have known, my thoughts went back to a plant with which I was familiar where the operator pulled a "boner," also the wrong switch with the results of a burned out 3000-kw. transformer and loss of income many times the actual damage. He lost his head. But why will an operator, who has handled a switchboard operation many times, suddenly lose his head? In this particular case, two plants were involved and the operators in both plants became rattled at the same time, although both had made the switch over and over again. Just mind wandering and lack of concentration on the job in hand.

DEAF, DUMB AND BLIND

One engineer I knew was a fine mechanic but was found to be tone deaf. He heard ordinary speech but could not distinguish between power plant sounds which are the guide to proper running condition. He was in charge of a fine plant during construction, did a good job and was in charge of operation until this peculiar defect was discovered. And it is not an isolated case. A number of high-pressure traps discharged into the storage compartment of a large filter in my present plant, with a resulting disagreeable cracking noise. By means of a home-made device, hot water and some steam was mixed with the low-temperature water before final discharge, so that only a slight hum remained. But the engineer on watch did not notice the difference for about a month and then didn't know what it was that had changed. Just tone deaf.

In another plant, fired with oil, a fireman has been in the plant for 2 yr. and has to read the meters at the start of his shift. One night the water pressure gage on the turbine boiler feed pump showed less pressure than the steam gage. There was plenty of water in the boiler and the feed-water meter showed no change in rate of flow of the feed but, instead of looking over the gage connections, he got the repair man out of bed at 2 a.m. to open a gage cock. He was *dumb* but that wasn't what the repair man said. In another year or so he may understand something about the gages he reads.

A wet spot where the floor has been dry; steam leaking around the gage glass; a little oil under an oil line; a black spot showing through the covering to an oil line; vapor rising from a pile of soft coal; boiler doors open a crack; small things in themselves but forerunners of trouble. The alert engineer sees them and acts accordingly. Others? Blind, just blind.

HE FORGOT

The chief orders that a certain thing be done at a certain time. A busy chief does not always have time to explain why, but he has his reasons. It isn't done because somebody, whose job it was to do it, forgot. Lives, time, money and property will probably be lost. Perhaps a serious accident occurs? All because one man forgot. He had not learned to follow orders. Here, written orders and an O.K. by the man who is to carry them out will help, but, if he forgets these, the result is the same.

MY TIME IS MY OWN

"Yes, I drink. But I'm always on the job next morning. The boss can't dictate to me how I shall spend my time off." You have probably heard this or similar expressions many times, as I have. A man's efficiency may be down 50 per cent because of some "good time" the night before but, if he is on the job, the boss is supposed to have nothing to say. But is the man's contention honest?

Here is a first-class workman. He is sober, anxious to please his employer, but is careless of his health. He exposes himself needlessly and becomes sick. A less efficient man must take his place. Has he been fair? His employer, his family and he, all lose and, if he goes back to work before he has recovered, his efficiency is low.

So we might go on—endlessly. The answer is things go wrong because some man doesn't do his whole duty effectively. For the tone deaf and the "dumb," jobs should be assigned that fit their capabilities. For the others—toe the mark or get out of positions of responsibility.

Oil Fired Boilers Heat Water for Outdoor Swimming Pool

FOR THE WORLD'S largest outdoor swimming pool, built by the San Francisco Park Commission, water is pumped directly from the Pacific Ocean. Usually the temperature of the water is too low for the comfort of the average bather; it was necessary, therefore, to install a heating plant, shown in the accompanying view. Since the installation of the heating plant the water in the pool has been maintained at a comfortable temperature, being circulated from the pool directly through four Ideal water-tube boilers by a 10-in. centrifugal pump, the water being warmed approximately 15 deg. at the rate of 168,000 gal. per hr. The boilers are fired with Fess crude oil burners.

FOUR OIL-FIRED BOILERS HEAT OCEAN WATER FOR SAN FRANCISCO'S MUNICIPAL SWIMMING POOL

The swimming pool can accommodate 10,000 persons at one time. It is 1000 ft. long and from 150 to 250 ft. wide and contains approximately five and a half million gallons of water, being 14 ft. in depth at one end and about 3 ft. at the other end.

Feed Water Heater Ratings Are Misleading

WHEN USED as a measure of the capacity of a feed water heater the term "horsepower" is misleading and is a common cause of misunderstanding between purchaser and vendor unless the basis of the horsepower rating is thoroughly understood.

One heater-horsepower is based on a capacity equivalent to the heating of 30 lb. of water per hour from a basic inlet water temperature to within 2 deg. to 5 deg. F. of the temperature of the exhaust steam. The basic inlet water temperature used by different manufacturers varies, some using 40 deg. F., others using 60 deg. F. This difference is not only confusing, but oft-times leads a buyer to purchase a heater having the highest horsepower rating, thinking such a heater will have considerable reserve capacity. As a matter of fact the actual capacity in pounds of water per hour of two heaters having different horsepower ratings may be the same. To illustrate the inaccuracy of horsepower ratings, we will analyze two heaters, one rated as 750 hp. on the basis of 40 deg. F. inlet water temperature and another rated as 825 hp. on the basis of 60 deg. F. inlet water temperature and reduce the capacity of both to pounds of water per hour with 40, 50 and 60 deg. inlet water temperature.

Rating of Heater, Hp.	Capacity in Pounds of Water Per Hour		
	40 deg. F.	50 deg.	60 deg. F. inlet temp.
750 (40 deg. basis)	22,500	23,625	24,750
825 (60 deg. basis)	22,500	23,625	24,750

This shows clearly that both heaters have exactly the same capacity for heating water although both have different horsepower ratings.

For feed water heaters the most accurate and the least confusing rating is in pounds of water per hour, heated from an initial inlet temperature (preferably the temperature existing at the plant where installed) to within 2 to 5 deg. F. of the temperature of the exhaust steam. This rating can be easily understood, different heaters can be fairly compared on an equal basis, and what is more important, no grounds exist for a misunderstanding between the purchaser and the vendor.

Dimensions of a feed water heater are determined by the pan system used for distributing the cold water and not by a formula. To secure the most efficient heater, experiments and tests are first made to determine the type of pan, the number of pans to be used and the method of distributing the water over the pan system so as to expose the maximum water surface to effective contact with the exhaust steam. These experiments and tests also establish the maximum capacity in pounds of water per hour and the cubical volume of the heater for that capacity when using the pan system adopted.

Some of the formulas commonly used in feed water calculations are as follows:

(1) To find the temperature of the feed water leaving the heater:

$$*T_2 = \frac{W_s (H + 32) + W_w T_1}{W_w + W_s}$$

(2) To find the weight of water in pounds per hour that can be heated by a given weight of steam:

$$W_w = \frac{W_s (H + 32 - T_2)}{T_2 - T_1}$$

(3) To find the weight of steam condensed by an open feed water heater:

$$W_s = \frac{W_w (T_2 - T_1)}{(H + 32 - T_2)}$$

where

T_1 = Temperature of the water entering the heater in degrees F.

T_2 = Temperature of the water leaving the heater in degrees F.

W_w = Weight of water entering the heater in pounds per hour.

W_s = Weight of steam entering the heater in pounds per hour.

H = Total heat above 32 deg. F. in exhaust steam in B.t.u. per pound.

*If more steam passes through the heater than can be condensed by the feed water, T_2 will have a fictitious value since T_2 can never be greater than the temperature of the exhaust steam.

Harrison, N. J. FRED B. APPLEGATE*

Bags in Boiler Shells

IN THE Feb. 1 issue, p. 226, T. P. Tulin writes that a fire made in the furnace under an empty boiler will cause the formation of a bag. I suspect he has not seen the experiment tried and that he is just stating what he believes will occur.

At a plant where I once was employed as engineer, there was an old, worn out, bricked in, return tube boiler, the furnace of which was used as an incinerator for old rubbish.

Every day the plate over the fire became red hot and, after some days, this part of the sheet became distorted to a considerable extent, but a real bag, such as is formed on a red hot plate when there is internal pressure, was never formed. Ultimately, a large hole was burned in the plate over the fire.

In another part of Mr. Tulin's letter he states that cases have come to his attention where bags have been formed with stoker fires having a rapid combustion rate, these bags being formed where there is no scale, oil,

*Manager, Pump & Heater Dept., Worthington Pump & Machinery Corp.

dirt, or other foreign matter on the inside surface of the plate and an abundance of water in the boiler.

Mr. Tulin must be mistaken, for otherwise we would be hearing about thousands of bags, since the rapid combustion of fuel under stoker fired boilers is the rule and not the exception. With clean sheets and sufficient water in the boiler I doubt if it would be possible to form a bag on a boiler sheet over the fire from overheat and pressure no matter how high the combustion rate.

In my own experience I have never come across a proven case such as Mr. Tulin describes in the concluding paragraph of his letter. The formation of bags or bulges because of defects, such as slivers, laminations, blisters or slag clots, as mentioned by Mr. Tulin, is possible but not at all probable. In times past such defects in manufacture were somewhat common, but so much care now is used in the manufacturing process that such defects in the finished plate are seldom found.

I do not believe a bag ever was formed on a steam boiler in use in a power plant when the plate was correct in construction and the surface clean and covered with water.

Toronto, Canada. JAMES E. NOBLE.

Changes in Piping Equalize Ammonia Temperature

IN FIG. 1 is shown the piping of an ammonia return line in a refrigerating plant. Due to the difference of temperature at the intake of the two compressors, there had been considerable trouble since that of No. 2 compressor was several degrees lower than No. 1. If an endeavor was made to hold the temperature of No. 1 compressor near the saturation point, corresponding to the suction pressure, No. 2 compressor would take liquid.

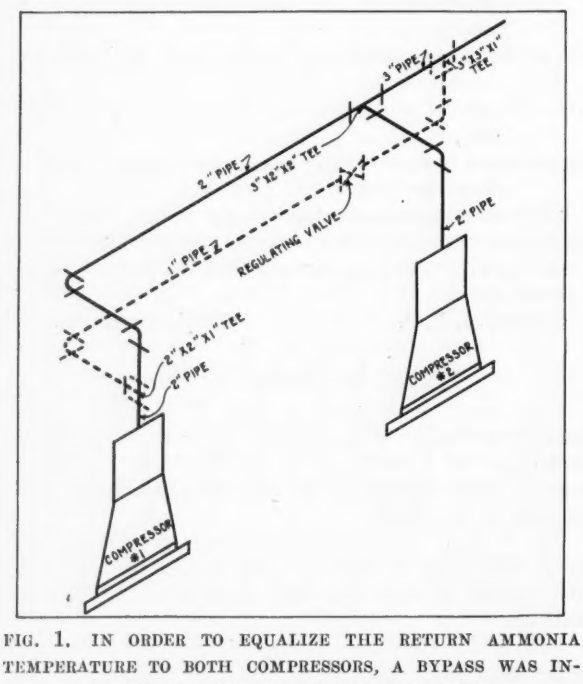


FIG. 1. IN ORDER TO EQUALIZE THE RETURN AMMONIA TEMPERATURE TO BOTH COMPRESSORS, A BYPASS WAS INSTALLED AS SHOWN BY THE DOTTED LINE

Reference to the piping diagram shows a 3 in. by 2 in. by 2-in. tee, which formed a pocket for any wet gas returning, causing it to settle at the bottom of the 3-in. line, and thus draining to No. 2 compressor. This difficulty was overcome by the installation of the 1-in. line, shown by the dotted line, which provides a drain from the 3-in. line to the 2-in. riser above No. 1 compressor. The 3 by 3 by 1-in. tee then acted as a separator and could be drained by adjusting the regulating valve in this 1-in. line.

This change has given satisfactory results in effecting equal temperatures on the returns of both compressors and also permitting the temperatures to be carried nearer the saturation point of the return gas pressure than previously.

Austin, Texas. A. GASS.

Editor's Note—Change in piping, as shown by the dotted line in Fig. 1, no doubt has given satisfactory results but it should be pointed out that this same equalization of temperature could have been accomplished with less work and a smaller amount of piping by connecting the 3-in. return line into the 2-in. line at a point midway between the two compressors. As shown in Fig. 2, a 2 in. by 3 in. by 2-in. tee could have been installed with the 3-in. side facing upward and then, by means of a 3-in. elbow, connected directly to the 3-in. main, as shown by the dotted line.

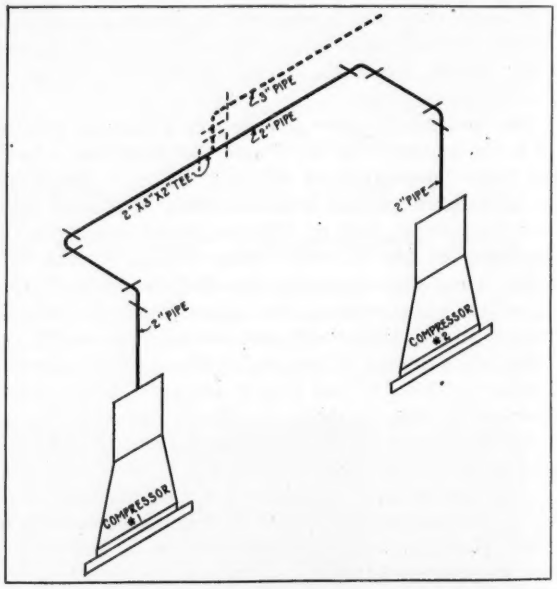


FIG. 2. EQUALIZATION OF TEMPERATURE COULD HAVE BEEN EFFECTED MORE EASILY AND WITH LESS EXPENSE BY THIS METHOD

Theory of Current Flow

YOUR interesting editorial in the Feb. 1 issue, p. 230, discussing Dr. Slepian's theory of the flow of energy in an electric circuit, should give rise to a great deal of thought on the part of all interested in this subject. Dr. Slepian's theory assumes that his electron fish could not be aware of any force or pressure existing within a conductor, but if such be the case I shall try to show that such a force does exist and that pressure can be ascertained within the conductor. First, however, it will be necessary to keep in mind the following three laws relating to currents flowing in conductors:

1. Current flowing in a conductor is directly propor-

tional to the electromotive force and inversely as its resistance.

2. Resistance of a conductor is directly proportional to its length and inversely proportional to its cross-sectional area.

3. Heat generated in a conductor is directly proportional to the square of the current, to the resistance, and to the time.

Now, let us consider the circuit to be a closed pipe and in every way the same as illustrated in your article, except that such pipe be filled with marbles and that the electron be considered, not as a fish in water, but as one of a number of entities existing within the pipe and bearing the same ratio in regard to size that molecules of water would to the marbles. It may be seen, therefore, that such entities could pass between the marbles and that the number passing would depend upon the force exerted on them and the number of spaces (cross-sectional area) open to their passage. Accordingly, if the marbles are assumed to be atoms and the entities to be particles of electricity or electrons, it may be seen that this represents not only the condition of things in an electric conductor, but it proves also that such entities would be aware of their motion and of the pressure.

Cleveland, Ohio. RALPH W. COWIN.

Editor's Note—By representing the atoms in a conductor by marbles in a pipe and the electrons as the molecules of water, Mr. Cowin gives us a fairly accurate picture of the conditions existing in an electric conductor. We do not agree with him in his statement that the entities would be aware of their motion. If endowed with intelligence they would be capable of determining their motion, but we see no reason for also concluding that they would be aware of the pressure.

Proper Selection of Prime Mover Will Show Saving

IN MOST paper mills the motive power for the machine room is supplied by individual steam engines, this method being considered economical as long as the exhaust is all used in the driers.

For an average mill, of 20 to 25 t. capacity using two machines, these engines develop about 60 hp. each and, on account of the small size of the steam plant, it is not considered worth while to design an elaborate installation for the sake of lower operating cost, but the simplest kind of a layout is preferred even though the operating costs are known to be higher than necessary.

Considering an output of 20 t. the steam requirements of the machine room will be 160,000 lb. every 24 hr., or 4 lb. of steam per lb. of paper produced. This gives a load of 6666 lb. of steam per hour and, including the steam used by the feed pump and line losses, the total load is 7000 lb. per hour where no main engine is necessary. As the power required in the machine room is 120 hp. in a mill of two machines, and 6666 lb. of steam is required, it is evident that the water rate of these engines can be as high as 55 lb. per hp. without producing an excess of exhaust steam to be wasted through the back pressure valve.

In this type of plant, the average steam pressure is about 125 lb. and the back pressure about 15 lb. Now if the engines are of the Corliss or other four valve type, the water rate can be kept down to around 35 lb. per hp. but with the best single valve engines the water rate will be close to 55 lb. As long as no exhaust is going out the back pressure valve, the engineer and those over him consider that the slide valve engine is as satisfactory as a more efficient type for such work, and being cheaper to install, it is frequently selected.

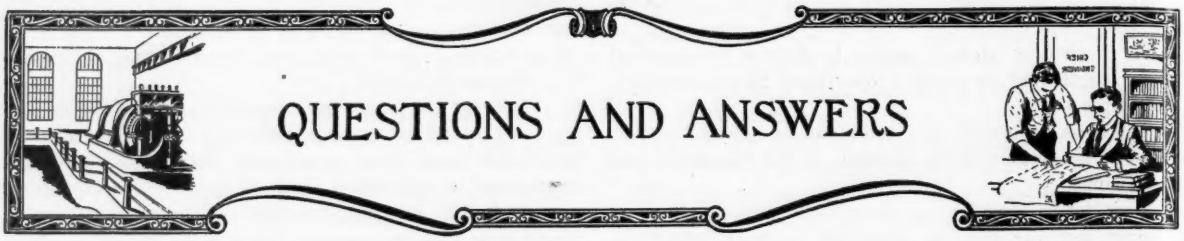
Of course, the plan of purchasing current to operate the machines is not economical, since the steam consumption would not be reduced, considering that a pound of live steam must be substituted for every pound of exhaust steam now used. But in many cases the slide valve engines with which these mills are equipped have water rates as high as 65 lb. per hp. especially where back pressures higher than 15 lb. are carried. If there is more exhaust than the driers can use it goes to the atmosphere as no exhaust is needed for feed heating where condensate from the driers at 212 deg. F. is available.

Accordingly, in the previously mentioned two-machine mill there would be 1200 lb. of excess exhaust—(65-55) × 120—and with a 24-hr. load this excess would amount to 28,800 lb. per day. This means burning 3600 lb. more coal daily than a correctly designed plant would call for. At $6 a ton the preventable loss is $3240 a year and this sum will pay the fixed charges on an investment of $10,000 at 12 per cent and leave a net saving of $2000 annually.

There are several types of engines that will prove economical for this work and we will consider the advantages of each. If a four-valve engine were bought, the cost would be around $50 per hp., so that the cost of a 60-hp. unit would come to $3000 and the steam rate would be reduced from 65 lb. per hp. to 45 lb. Even if only one engine were replaced, the 1200 lb. of excess exhaust would be eliminated and the initial cost repaid in less than a year.

Assume another case where conditions in the machine room are such that the exhaust is all condensed in the driers, as in the case of engines with a 55 lb. water rate and 6666 lb. of steam is needed for drying. Apparently this is an economical plant as far as the machine room is concerned, but suppose that current is being purchased for the operation of some department in the mill, the electric load being 100 kw-hr. or more. At 1½ cents per kw-hr. the bill for current is $36 daily or $10,800 per year. In this case slide valve engines with a rate of 55 lb. per hp. could be replaced by more economical four-valve or uniflow engines which could be supplied with superheated steam and the water rate cut in half. These engines could drive generators supplying current for the operation of the machines, thereby eliminating friction losses involved in mechanical transmission. With a water rate of 22.5 lb. per hp-hr. an engine of this type would develop 311 hp. on the 7000 lb. of steam used by the present plant. This is 191 hp. more than the 120 hp. required, and this excess power could be used in other operations, thus reducing the electric power bill or eliminating it entirely, if the electric load is not over 125 kw-hr. Cutting 125 kw-hr. from the purchased power demand at a cost of 1½ cents a kw-hr. will save $13,500 per year. This saving is three times the fixed charges involved in installing the necessary equipment. The engine, generator and motors would not cost over $15,000 since a 200-kw-hr. generating unit of the most efficient type can be secured for $60 to $70 per kw-hr. Allowing $5000 for a superheater, the fixed charges on $20,000 at 12 per cent are only $2400 a year, leaving a net saving of $11,000 a year. Labor costs are not increased as one engineer and one fireman are required on each shift with any type of plant.

Springfield, Mass. A. F. SHEEHAN.



Comments on Corliss Engine Diagrams

IN REPLY to the inquiry concerning the indicator diagrams p. 339, March 1 issue, I am of the opinion that, with certain changes, the engine could be made to do more work. It might be done either by increasing the speed or

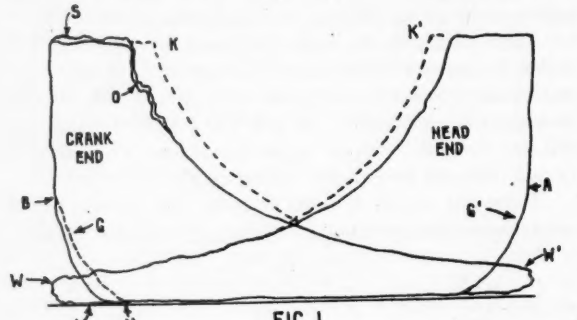


FIG. 1

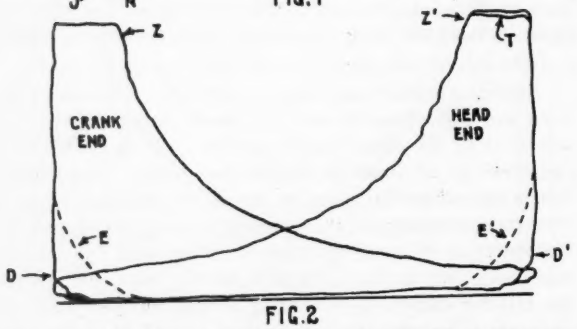


FIG. 2

THESE CARDS WERE TAKEN FROM A 15 BY 30-IN. CORLISS ENGINE WITH SINGLE ECCENTRIC, RUNNING AT 72 R.P.M. AND BOILER PRESSURE 120 LB.

the boiler pressure, but, since the latter already is 120 lb. it may not be possible to raise it. Then, if the speed were increased it would require a larger drive pulley on the main shaft to keep the latter turning at its present speed, which may be out of the question, although 72 r.p.m. is not high.

Since the engine has a 15 by 30-in. stroke, it appears from Fig. 1 that it is cutting off at about ¼ stroke or about 7 in. of the piston travel. Having a single eccentric, of course it could not cut off as late as with a double eccentric since any change on the steam valve adjustments would produce early or late action on the exhaust valves, or otherwise the steam and exhaust valves both would be opening at the same time. Hence the range of adjustment for late cutoffs on a single eccentric Corliss engine is limited to 2/5 stroke or about 12 in. of the piston travel on this engine.

Figure 1 is satisfactory for this engine, although the crank end shows less compression than the head end. The exhaust valve appears to close at about point *J* instead of at *N*, which would bring the line the same as the dotted line *G*. This compression line appears a little wavy where it merges with the steam admission line and the two steam lines at S, of different heights make it appear that the steam admission is a little early compared with the head end diagram, where the compression at *G'* is satisfactory and admission occurs about the point *A*. The crank end dashpot may be bouncing or not closing properly at each stroke, perhaps due to water getting into the dashpot and not being expelled as quickly as the air used for cushioning. Again, loose brasses or worn pins connecting the steam rods to the wristplates and the hook bell crank may cause some such fluctuations in the lines. If the dashpot rod is loose on its pins it may produce waves similar to the expansion line at *O*, although a sluggish dashpot may cause sufficient leakage through the valves to hold up the expansion line as indicated on both diagrams, thus producing the high terminal pressure at *W* and *W'*.

It appears that leakage at the exhaust valve on the crank end, causes the sharp turn at *J*, a slight wave at *B*, and also has some effect on the waves at *O*. If it is possible to open the exhaust pipe at a point where the discharge will be visible I would advise testing this valve for leakage by admitting steam to this end of the cylinder while it is closed. On the crank end the rounded point of cutoff indicates a worn latch plate and block which should be provided with square edges and as little lost motion allowed between engagement as possible, about 1/32 in. to 1/16 in. at most. This rounding of the cutoff is caused also by the worn tripping cam or roller and a worn tail plate on the end of the latch.

In Fig. 2 the exhaust valves close late for compression and on a single eccentric Corliss engine this would cause late release also. There should be more compression than shown at *D* and *D'*. This may be effected by lengthening or shortening the exhaust valve connections to the wrist plate, as the case may require, thus bringing compression nearer to the dotted lines *E* and *E'*. At *T* there is a double steam line which may be caused by water in the dashpot or irregular closing of the valve. After refitting all of the above mentioned parts, I would advise inspection of the reach rod ends and pins, even the governor itself, as failure to release often is caused by wearing of these parts.

By extending the point of cutoff to its limit of 2/5 stroke it may be possible to make the engine do more work by lengthening or shortening the reach rods slightly. This will bring it nearer the dotted lines *K* and *K'* shown in Fig. 1. To decrease the lap the steam valve connections from the hooks to the wristplate may be shortened or lengthened, depending on whether the valves are opened by push or pull movement. In such cases, however, care must be used not to have the steam valves opening too early. In many cases an adjustment of 1/32 in. or 1/16 in. will have considerable effect in increasing the power of the engine.

Cambridge, Mass. R. A. CULTRA.

IN REGARD to the indicator diagrams, p. 339, March 1 issue, I would say that, although both sets of diagrams show a tremulous action of the indicator itself, the general outlines of the head and crank end diagrams of both Figs. 1 and 2 seem to indicate good valve setting and steam distribution in the engine cylinder. The lead lines, steam lines, expansion curves and back pressure lines—all are as they should be.

Possibly the compression may be reduced as now shown in Fig. 1 and by so doing the exhaust valves would open earlier, thus making a slight improvement in the economy of the engine.

For economy in that type of engine the load appears to be satisfactory, but there is no real reason for not increasing it if required in an emergency. To obtain more power, put on more load; since the automatic features of the engine valve gear and governor will take care of that. If these diagrams are fairly representative of operating conditions, there should be no reason for complaint. Better diagrams are seldom seen. It would be interesting to hear something further about this engine.

Brooklyn, N. Y. CHARLES J. MASON.

ACCORDING to the indicator diagrams published in the March 1 issue, page 339, the engine from which No. 1 diagram was taken can carry about 50 per cent more load with a little change in the valve setting, though the economy will not be so good as at present. To make this change, cut down the lap on both steam and exhaust valves and adjust the eccentric to a smaller angle of advance.

To make this adjustment, first set the wristplate at mid-position and adjust the steam valves to not more than one-third their present lap. From the appearance of the diagram I assume that these valves now have ¼ to ⅜-in. lap, which could be cut down to ⅛ or 1/16 in.

The exhaust valves perhaps have ¼-in. lap and might be adjusted to 1/16 in. or less. Then hook up the valves and move the eccentric back to get about 1/16-in. lead on the steam valves.

This change will allow the desired increase in load, though you will now have a much later compression, something like diagram No. 2. Some economy will be sacrificed in this way, though this is not serious, and an engine running at this speed, 72 r.p.m., should run quietly with practically no compression.

Springfield, Mo. ROSS E. THOMPSON.

Figuring the Power for a Motor-Generator Set

WHAT IS the average amount of power required to operate a synchronous motor-generator set if the motor input is rated at 125 hp., the output 112 hp., 2200 v., 28.4 amp., 2 phase and 60 cycles? The direct current generator is rated at 75 kw., 125 v., 600 amp. and the power factor is kept at 100 per cent. Instruments on the generator shown 110 v. and 400 amp. L. I. P.

A. Attention should be called to the rating of the synchronous motor, which is given as 112 hp. output and 125 hp. input. Further information is 2200 v., 28.4 amp. per phase, 2 phase, 60 cycles. The latter data are not consistent with the horsepower rating.

With 2200 v. and 28.4 amp. the motor should have a rating of 125 kw. rather than horsepower. It appears, therefore, that the 112 and 125 hp. referred to should be 112 and 125 kw. or, as it is sometimes termed, electrical horsepower. In figuring out this problem, we are going on the assumption that the rating is 112 kw. output and 125 kw. input.

To calculate the amount of power necessary to operate the motor generator set when the d.c. generator is delivering 44 kw., it is necessary to know the efficiency of both the d.c. generator and the motor for that particular load. This can be obtained either by direct test or from efficiency curves of this particular machine, furnished by the manufacturers. In the absence of more specific data in this respect, we will assume certain efficiencies.

When delivering 44 kw., the generator is operating at about 60 per cent load. Assuming that it is a shunt wound motor, from a study of various efficiency curves, the efficiency at 60 per cent load probably will be around 87 per cent and the mechanical load on the synchronous motor 44 ÷ 0.87, or 50.6 kw. 50.6 ÷ 112 gives 45 per cent load on the synchronous motor and again, from reference to various characteristic curves, we find that at this load the efficiency of the motor will be in the neighborhood of 88 per cent. The input to the motor under these conditions will be 50.6 ÷ 0.88, or 57.5 kw. In other words, when the direct current generator is carrying a total load of 44 kw., the input to the alternating current motor will be 57.5 kw.

Chemicals for Gas Analysis

FOR THE analysis of furnace or flue gases, what chemical reagents are needed and how are they prepared? J. H. B.

A. Sodium or potassium hydroxide is needed for CO_2; for oxygen absorption there are several solutions which may be used, but the best probably is an alkaline solution of pyrogallic acid; for carbon monoxide, either an acid or ammoniacal solution of cuprous chloride may be used.

Recommendations by the Bureau of Mines are as follows: for carbon dioxide absorption—330 gm. potassium or sodium hydroxide are dissolved in 1000 c.c. of water. Potassium hydroxide is more effective but also is more expensive than sodium hydroxide.

Oxygen absorption can be made by making up a reagent in two steps. First, make solution (A) by dissolving 600 gm. KOH in 400 c.c. of water, then prepare solution (B) by dissolving 25 gm. pyrogallic acid in 75 c.c. of water. After (A) has cooled, slowly pour (A) into (B) and exclude air at once.

For the absorption of carbon monoxide, an ammoniacal solution of cuprous chloride is made by adding 250 gm. ammonium chloride (NH_4Cl) and 200 gm. cuprous chloride (Cu_2Cl_2) to 750 c.c. of water. This mixture should be shaken thoroughly, allowed to settle for several hours, and the clear liquid then decanted. To the latter, slowly add, while stirring, (NH_4OH) aqua ammonia (Sp. Gr. 0.90) until the deep blue color just persists. Be careful not to add an excess of ammonia. Exclude air at once, as this solution will absorb oxygen from the air almost as readily as the pyrogallic acid solution.

In the procedure of gas analysis, all of the carbon dioxide first must be absorbed before proceeding with the oxygen absorption, as the pyrogallic acid solution will absorb CO_2 as readily as the caustic potash.

In like manner, all of the oxygen must be removed from the gas before passing it into the cuprous chloride solution as the latter will absorb oxygen also.

EDITORIAL COMMENT

What the Engineering Salesman Can Bring

In the engineering field is an expensive, specialized service which, difficult to define, has been developed by manufacturers to meet the economic needs of a highly organized and competitive industry.

Carried by legions of "men on the road," to every section of the country, engineers have learned to rely upon this service as the only practical method of personal contact with manufacturers, when considering improved methods and new equipment. At other times the service may be interesting, embarrassing or annoying, depending upon the individual characteristics of the men.

Business courtesy, which the engineer must accept with responsibility, demands certain considerations for even the humblest caller. These calls should be occasions of mutual satisfaction and a credit to both organizations. The engineer's attitude determines largely whether the hours so spent are profitable, enjoyable or simply endured.

The "traveling salesman," who sells anything from safety pins to steam rollers with voluble fluency, knowing nothing of the article but its name, deserves little serious consideration. But there is another type, the manufacturer's representative, often a technical graduate, always well trained by the manufacturer in the theoretical and practical application of their equipment. These men usually cover a large territory, come in touch with new and interesting installations, keep posted on current technical literature and are well informed by their employers of important developments in their line.

They are specialists, can discuss theory or practice and are always on the lookout to make friends and give information. They request, in return, courteous treatment and unbiased consideration of their equipment when purchases are made.

These men, known as salesmen, engineers, and service men, form an engineering clearing house. Many of them are equally at home in the engine room, drafting room, or office. Their business is to be of service to the industry and they can talk intelligently to anyone in the organization from a coal passer to the general manager. The service is gratis but, like all free service, has a string attached. You pay indirectly with each piece of equipment purchased and the many hours tied up in conversation. You pay for the service regardless. Why not knuckle down, use the service and get your money's worth? Don't stop with a cigar and a joke, find out the equipment details in the latest station described in your magazine, the conditions which put one manufacturer's equipment in this plant and a competitor's in that.

How about some of the little puzzling questions that came up while you were reading that article on feed water treatment? What about some of the difficulties encountered in describing the automatic control for hydro plants? How can that new motor be used to advantage in your plant? Has it been applied to your particular problem before? Where? With what results?

There are a dozen different angles to each problem. Find them all. Your men have questions to ask which, if properly answered, will help them and save the company money. Find out what a valuable service walks into your office, or engine room, each day with a brief case, a price book and a handshake.

The Public Utility Is a Sound Institution

From the 1925 annual report of the American Telephone and Telegraph Co., which has just come to us, we find that during the year 813,000 telephones were added to the Bell system, bringing the total number installed to over 12 million. Add to these, the 4 million owned by independent companies but connecting with the Bell system, the total number of telephones installed in this country comes to 16,720,000. Further on in the report, it is shown that the total number of persons employed is over 332,000, and that the stockholders number 500,000.

This report, perhaps the most eloquent argument against government ownership of utilities that could be advanced, reflects the success of the public utility, privately owned but publicly regulated, as we know it today.

The telephone business is of a highly intricate, technical and complicated character. If anybody in New York suddenly finds it necessary to talk to somebody in San Francisco, Gopher Prairie or Yonkers, he merely lifts his receiver from the hook and tells the operator to whom he wishes to talk and in the course of a few minutes or an hour, depending upon circumstances, he is connected with the desired party. This simple operation is not one to induce in the average unthinking mind speculations of anything more than commonplace character. Yet back of this simple operation, back of the transmitter, is an organization, the parallel of which has never before existed. The average John Smith never gives it a thought. He does not realize when he lifts his receiver from the hook that a hundred thousand people have labored for forty years to make possible the feat of talking across the continent. He does not see the army of efficient employees posted along the thread of wire that stretches for three thousand miles across the plains and mountains of the United States, who establish his connection and guard its continuity while he talks. He does not see the 5000 highly trained workers in the great research laboratories on West Street who toil endlessly so that the apparatus he uses may be perfect. He does not see the wonderful manufacturing plant at Hawthorne employing over 25,000 people or the new plant at Kearny where the equipment used on the Bell system is made. Nor does he realize the faith and confidence which a half million stockholders have in the organization which enables him to talk at will to San Francisco or Gopher Prairie.

An amazing organization! Notwithstanding its size, however, its many corporations and various intercorporate relations, it is quite simple in principle. It is not only the best but possibly the only form of organization that could successfully operate a nation-wide system of interconnection under American laws and traditions.

The principles upon which the Bell system is organized are the same as those upon which all of our privately owned utilities are organized. The success of the A. T. & T. Co. is duplicated in a thousand electric light and power companies all over the United States. True, these utilities are not so large and their annual reports are less impressive but their financial stability and service rendering character is the same.

Like the telephone business, the business of supplying electric power and light throughout the United States is a complex one, demanding not only constant development and improvement but a broad vision into the future. Just as the telephone companies are planning to satisfy the nation's communication requirements for years to come, so are the electric light and power companies preparing to satisfy the nation's power requirements, ten, fifteen and twenty-five years ahead. In the Electric Power Survey of the Great Lakes Division just completed by the Power Survey Committee of the N. E. L. A., we find, for instance, that the per capita production of power in 1950 will be 1942 kw.-hr. per annum, over three times the per capita production today. This figure is not a guess as many such figures are. It is based upon the most thorough, painstaking survey ever made of all contributing factors that enter into the power requirements of the area considered. For four years a committee composed of the most competent engineers in the field, labored in collecting, compiling and analyzing the material for this report.

Such work takes time, effort and capital. No individual can undertake it. It is only through an organization such as the N. E. L. A., maintained by the electric light and power companies of the country, that it can be accomplished and the results utilized successfully.

The privately owned, publicly regulated utility is a sound institution, based on correct economic principles, and one that has proved its worth by years of high quality service and substantial dividends on the capital invested. Any organization, such as the A. T. & T., whose report we cite, that can successfully control a capital of over a billion dollars and can render high quality service to 114 million people, at the same time meeting the needs of the future, fully justifies its existence.

There's More to First Aid Than Using the Prone Pressure Method

In going over the article on first aid treatment that appears in this issue, abstracted from the latest N.E.L.A. report on the subject, the reader will note that we have omitted any discussion of the prone pressure method of resuscitation. This method, in cases of drowning and electric shock, has proved to be the most effective operation ever devised for restoring consciousness, provided the patient is not seriously injured in such a way as to make its use inadvisable.

In avoiding present discussion of this point, it is not our intention to minimize in any way the importance of the method or the desirability for every person, young and old, whether employed in industry or not, of a good working knowledge of it. But the prone pressure method has received so much more publicity in the general and technical press than that given to some of the points we have mentioned, that we feel justified in emphasizing the latter at this time.

Much has been done during the past few years to decrease the accident toll taken by industry but it seems that, in spite of everything we can do, accidents still occur. Many of them are in themselves unimportant but, as brought out in the report, much pain can be prevented and subsequent treatment by a physician can be made easier by proper first aid treatment. At the same time, complications set up by infection, which would lead to serious trouble later on, can be avoided. The most important thing is asepsis—cleanliness, prevention of infection. Next is the importance of calling a doctor as soon as possible and of telling him as accurately as may be the cause of the injury and the treatment already given.

We wish to call particular attention to the fact that the N.E.L.A. report on first aid treatment was not intended as a guide for those studying the subject but as a teaching manual for those who give instruction in it.

Many industrial organizations and public utilities are co-operating in the important work now being carried on to make modern industry as safe as possible. We need not discuss here ways and means for carrying out this plan. We feel, however, that the report mentioned above forms a most useful and practical aid to any engineer who wants to do something definite in his own organization to further this great movement for safety.

Special Rates and the Ice Plant

One of the most difficult problems confronting the manager of a central power station is to obtain a load which is uniform throughout the day. There are few public utility generating plants, except base load plants, that can secure a load factor greater than 60 per cent, in most cases the load factor is below 50 per cent. This condition has brought about the practice of giving reduced rates to industries using power steadily, provided they reduce their load during the hours of the day when the peak load is on the system. For similar reasons, public utility companies have found, in some cases, that they can profitably take on the load of office buildings during the summer months, the idea being to use the generating equipment in the plant at its most efficient load point as much of the time as possible.

Among the industries so favored is that of ice-making and refrigeration and the increased growth of electric driven ice plants is a result. Undoubtedly the rates which are offered are based on the load curve of the station and are somewhat arbitrary. Because of this, some managers of ice-making plants have found that by juggling their load and paying the penalty for overload once, they can save in the long run on their power bill. Just how this has been done was discussed at a recent meeting of refrigerating engineers, reported in this issue.

Inasmuch as a number of other industries use purchased power on a similar basis with a penalty attached for exceeding a given limit during peak load periods, a study of the methods employed will undoubtedly suggest ways in which the power bill may, in many cases, be held in control without interfering with production.

POWER PLANT ENGINEERING DEVELOPMENTS AND NEWS

New Crawler Loader Handles 140 T. an Hour

DESIGNED TO HANDLE crushed stone, gravel, sand, phosphate and similar materials at a rate of 1¾ cu. yd. a minute—about 140 t. an hour—a new Crawler Loader has just been announced by the Link-Belt Co. of Chicago, Ill. Four units compose the loader; i.e., the elevator, the chassis, the power plant and the crawler. Driving, operation, and care of this new loader can be handled entirely by one worker.

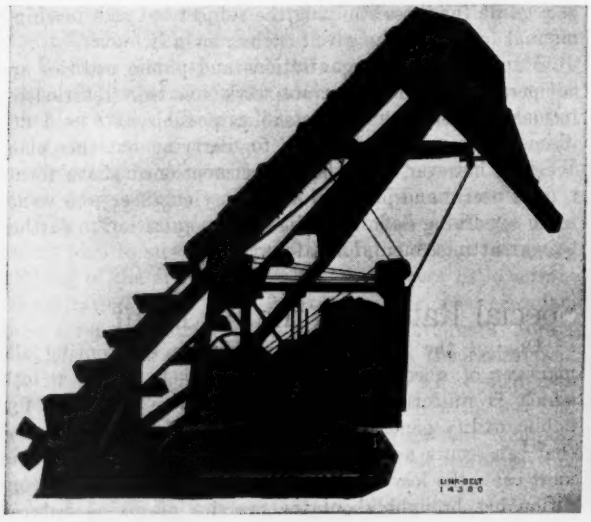


FIG. 1. GENERAL VIEW OF LOADER, SHOWING ELEVATOR, FEEDER, POWER PLANT AND CRAWLER

Starting, turning and stopping of the loader are all controlled by two hand levers, which automatically apply brakes when stopping. The elevator is controlled by separate hand lever, which operates a steel clutch and disengages automatically when machine is started in reverse. Reference to Figs. 1 and 2 will show the arrangement and details of construction.

Buckets are of special design, with reinforced edges to reduce wear and spaced close to insure a steady delivery of material to the chute at the head of the elevator. Head and foot sprockets are made of manganese steel, cast in two parts, and clamped on hexagonal steel shafts, which are journaled and run in babbited bearings, oil-grooved and provided with Alemite fittings. The driving wheel on the elevator head shaft is provided with a safety breaking pin.

At the head of the elevator, the chute, as ordinarily furnished, is of the swiveling type, operating through an angle of 180 deg. and controlled from the operator's platform. The feeder, shown in Fig. 2, consists of manganese steel paddles, securely bolted to the hexagonal steel foot shaft and arranged to produce a steady feed of material to the buckets. Feeder adjustment and collapsing mechanism are both controlled by a hand wheel within reach of the operator. Link-Belt Co. used a similar type of feeder as far back as 1905 in conjunction with a flight conveyor on an adjustable car unloader.

The chassis of the loader is made of heavy angles, plate and channels, securely riveted together. A large steel casting is riveted to the chassis, forming a support for the chassis, and for the connection to front crawler shaft as well. The rear of the chassis is supported on a large steel bracket casting, pinned to the rear axle.

FIG. 2. LOADER HANDLING CRUSHED STONE SHOWING OPERATION OF FEEDER

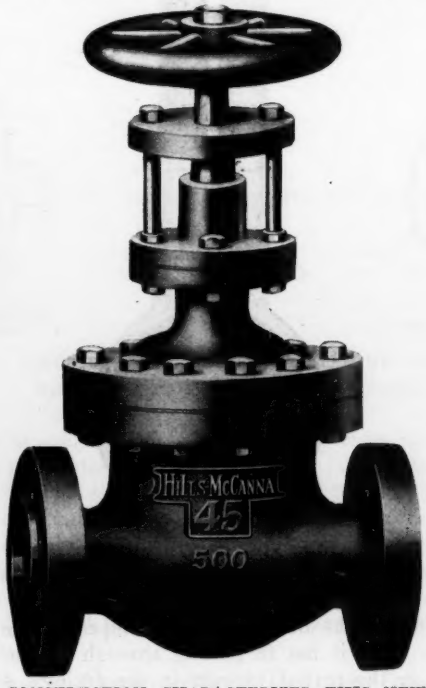
The power plant, shown in Fig. 1, is a gasoline engine unit of 30 hp. at 1200 r.p.m. equipped with a governor; electric motor equipment can also be furnished to suit the conditions. The truck transmission has three speeds, giving a speed of 33 ft. per minute or 66 ft. per minute in the forward direction, and 29 ft. per minute in the reverse. All shafts are of turned steel, all gears cut steel, and all bearings bronze-bushed. The housing is dust tight, and partly filled with oil which assures sufficient lubrication to all parts. The drive from engine to machinery housing, and drives from machinery housing to crawler, are all roller chains, running on steel sprockets. All drives are protected by sheet steel guards.

The crawler is of channel and plate construction, riveted together, making a rigid housing for sprockets and idlers. Sprockets are of the Link-Belt patented self-cleaning type, made of steel, bronze-bushed. The treads are made of special heat-treated steel, cast in one piece, 11 in. wide, $11\frac{5}{16}$ in. pitch, and run on cast steel idlers,

also bronze-bushed, with large chambers for lubrication. Alemite lubrication is used throughout. A special design of shoes and sprockets insures self-cleaning crawler traction tread. Rollers are of large diameter and keep the bearings up out of the dirt.

Valve for 500-lb. Service Is Made of Hills-McCanna 45

FOR SOME TIME the oil industry, as well as other industries handling acid and corrosive materials, has been a field for the use of metal parts that would resist such corrosion and wear, stand up under the high temperatures often involved and at the same time have great strength. One metal that was developed for this purpose is known as Hills-McCanna 45, and its application is being extended to include the high temperature and high pressure conditions now coming into being in the steam power plant. The valve shown in the accompanying illustration is made of this metal, for pressures up to 500 lb. per sq. in., by Hills-McCanna Co., Chicago, Ill.



RUGGED CONSTRUCTION CHARACTERIZES THIS NEW HIGH-PRESSURE VALVE

These valves are available in globe, angle, Y and other types. They can be made in light sections for 125 lb. pressure and in the type shown for 500 lb. pressure. All parts are made extra large for regrinding and are designed to eliminate the possibility of gates being disengaged after the seats are reground.

Hills-McCanna 45 is a high tensile bronze with a strength equal to that of steel and is essentially a pressure metal. Its dense, smooth, close-grained structure eliminates the necessity for heat treatment for pressure work. It weighs 0.27 lb. per cu. in., comparing closely with steel at 0.278. An entire device may be constructed of the alloy, eliminating the possibility of electrolysis or galvanic action. Tests have indicated that it suffers no permanent growth or set on repeated heating and cooling.

Lead Coated Economizer Has Extended Tube Surface

AS A result of several years of experience with the cast-iron tube economizer and the steel tube economizer with plain, lead-coated tubes, B. F. Sturtevant Co. of Hyde Park, Boston, Mass., has recently put on the market a new type of extended surface lead-coated economizer known as type Y. This apparatus consists essentially of groups of headers connected by lead-coated, extended surface steel tubes, as shown in Fig. 1, through which water circulates;

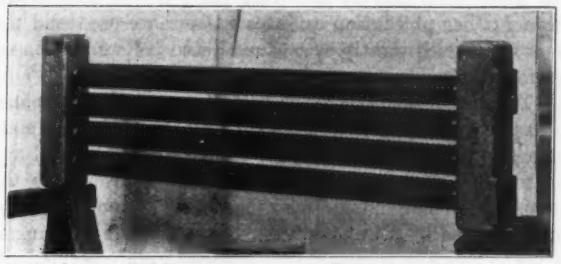


FIG. 1. STEEL TUBES WITH DISCS ARE LEAD COATED AND EXPANDED INTO HEADERS

these headers are supported on an angle frame work, as in Fig. 2, covered with a suitable casing, inside of which the flue gas transfers heat to the tubes.

Construction of a section of the Type Y economizer is shown in Fig. 1. A method of putting steel disks on the pipe has been developed that secures the disk so tightly that it makes an indentation in the pipe, thus securing good heat transfer. Pipes are rolled into the headers as in boiler construction. A 180-deg. bend connects one section

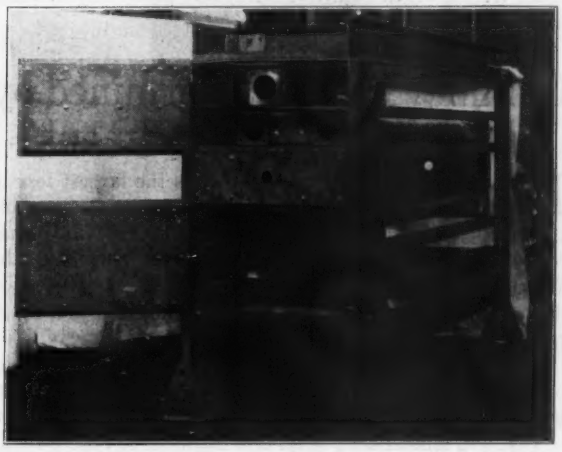


FIG. 2. SECTIONS ARE SUPPORTED ON ANGLE FRAME, CONNECTED BY 180-DEG. BENDS AND COVERED WITH SUITABLE CASING

to the one above. All these connections are on the front of the machine, where it is easy to get at them by simply opening the doors, as shown by Fig. 2. Holes in the headers opposite the pipes are provided for rolling the tubes, inspection and cleaning. These are closed by means of a tapered cap, as shown in Fig. 1.

Figure 2 shows clearly the method of supporting the sections. The headers rest on angles which in turn are

carried by the corner columns. By supporting each section independently on angles, it is necessary only to remove two bends in front and draw out the section without disturbing the adjacent ones in order to make repairs. Frames are provided as shown at top and bottom for flue connections. Between groups of six sections each a space is left for soot-blower elements.

Every precaution has been taken to insure tightness of the machine and the maximum heat insulation. On the front of the machine are provided doors filled with 2 in. of insulating material. The fixed panel between doors is also insulated. The door is sealed by the plate at the back of the fixed panel and by the front plate of the door itself. As a further precaution asbestos gaskets are used and the door is fastened tightly by means of stud bolts and nuts on all four sides.

The side covering consists first of a steel plate or panel next to the supporting angles. Next to the steel plate panels is put a layer of 2½ in. of insulating material and on top of this another steel plate bolted through to the inner plate. The outside plate is flanged around its edges and is bolted to the channel flanges. This side covering is made in this way so that it will be kept in place permanently, consequently it is divided into as few panels as possible. At no place is there a butt joint extending through the covering. Generous laps are provided along all the edges and at the same time provision is made for expansion.

Two relief valves and one blowoff valve of approved make are furnished with each economizer. Headers are tested up to 1000 lb. hydrostatic pressure with hot water after machining. Sections are shipped completely assembled and are installed in their supports as soon as received at the plant, thus insuring a minimum amount of time for erection. After erection, the complete machine is again tested, which insures against any possibility of leaks in headers, caps or joints.

Chimney Losses Determined by New Uehling Instrument

HEAT WASTED up the chimney is the largest loss in any boiler plant and its measurement is so important that the Uehling Instrument Co., of Paterson, N. J., has recently perfected a recording instrument known as the Waste Meter. With its aid, the fuel wasted may be readily determined either in dollars and cents or in B.t.u. or in per cent of the fuel burned during any time interval.

Temperature of the escaping flue gas and percentage of carbon dioxide (CO_2) are recorded on the same chart by this meter. The corresponding fuel loss for any amount of CO_2 and temperature may, it is claimed, be read directly from a table furnished by the manufacturer. By having the CO_2 and temperature recorded on the same chart, the engineer is enabled to determine whether special efforts were made to increase the CO_2 during heavy firing periods, when the temperature naturally rises.

To minimize the chimney loss, it is essential to reduce the temperature of the escaping gases as much as possible, but it is even more necessary to increase CO_2 to the practical maximum percentage because the higher the CO_2, the less will be the sensible heat wasted up the chimney, regardless of the kind of fuel burned; furthermore higher CO_2, in itself, reduces the stack temperature materially.

With the aid of the CO_2 record, it is comparatively easy for the fireman to control the air supply in order to keep the CO_2 fairly constant at any desired percentage. The temperature of the flue gases, however, is dependent upon the rate of driving the boiler, the cleanliness of the boiler heating surfaces and the condition of the baffles. Hence the pyrometer record shows when the soot is blown, when scale is removed from the boiler and it also shows up bypassing of the gases due to leaky or broken-down baffles.

In the Waste Meter the pyrometer element is operated by the varying quantity of air that will flow through an orifice at different temperatures. Referring to Fig. 2, air is drawn in succession through the two orifices A and B under constant suction. Orifice A is at the temperature to be measured, while orifice B is maintained at a constant temperature.

FIG. 1. THE UEHLING FUEL WASTE METER RECORDS CO_2 AND FLUE GAS TEMPERATURE ON THE SAME CHART

So long as the air has the same temperature in passing through A as it has in passing through B, there is no change in the partial vacuum in the enclosed space between the two orifices; if, however, the temperature of orifice A increases while that of B does not change, then orifice A will offer greater resistance to the inflowing air and in consequence the suction or vacuum between the orifices will increase.

In the application of this principle to the pyrometer, orifice A is located in a tube which is exposed to the heat to be measured, while orifice B is kept uniformly at 212 deg. F., by the exhaust steam from the aspirator of the CO_2 element. Adequate filters are provided for keeping the orifices clean permanently without attention.

Orifice A is made of platinum and is located at the end of tube 105, Fig. 2, which is protected by an outer tube 106, the inner tube 105 connecting with orifice B by copper tubing 104. Pyro-porus filter disks 107 and 114 clean the air perfectly without offering measurable resistance to the air flow. The air from the atmosphere is thus drawn

through pet cock 109, filter 107, becomes perfectly clean, passes between the inner and outer tubes to the end of tube 105 where it acquires the temperature to be measured and then passed through orifice A at this temperature. The amount of air which enters A depends upon its temperature and this air is transmitted through tube 105 and 104 to orifice B.

Fire tube 106 is permanently located in the last pass of the boiler or wherever else it may be desired to record the temperature and the changing vacuum between the orifices is transmitted through tube 118 to the temperature side of the Waste Meter where it actuates a bell floating in mercury to which is attached the recording pen. The pen travel is calibrated in degrees Fahrenheit for the desired range of temperature.

For actuating its CO_2 pen, the Waste Meter employs the Apex CO_2 Meter. The latter instrument is similar to the pyrometer element, described above, excepting that its orifices are both maintained at the same temperature and the changing vacuum between the two orifices depends upon the absorption of the CO_2 constituent of the gas by means of a dry cartridge. The constant suction steam aspirator of the Apex CO_2 meter also develops the suction for the pyrometer element, while at the same time keeping orifice B of the temperature element at 212 deg. F.

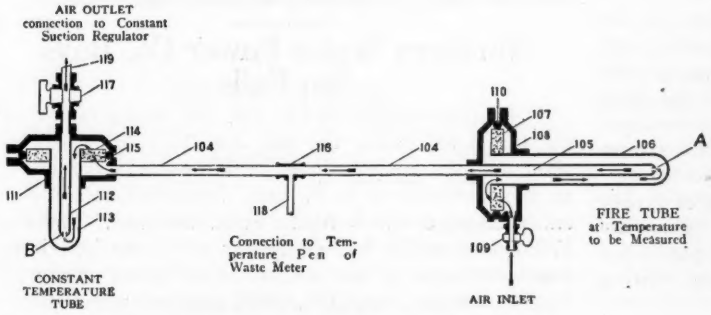


FIG. 2. ILLUSTRATING SIMPLE PRINCIPLE OF THE PYROMETER ELEMENT OF THE WASTE METER

Several unique features are embodied in the Waste Meter, such as the entire absence of moving parts, rubber connections or special glassware. It employs no chemical solutions, and is self-checking for accuracy. The records are made almost instantaneously and are continuous.

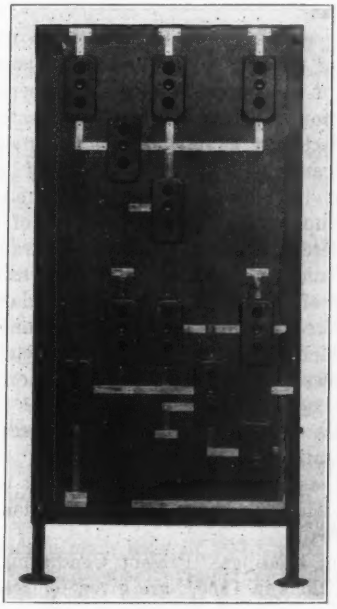
Northern Connecticut Power Company Formed by Merger

CONNECTICUT PUBLIC UTILITIES COMMISSION on Mar. 5 granted approval for the merger of six power companies in the northern part of the state, to be known as the Northern Connecticut Power Co. The six companies, all owned by J. G. White & Co., Inc. of New York City, are the Connecticut River Co., the Northern Connecticut Light & Power Co., the Thompsonville Water Co., the Stafford Springs Aqueduct Co., the Northern Connecticut Power Co. and the Somers Electric Co.

Headquarters of the new company will be located in Hartford and present plans call for a $200,000 temporary plant pending the development of a $6,000,000 hydro-electric project at Windsor Locks, Conn. Walter P. Schwabe of Thompsonville has been elected president of the new company; vice presidents, Loring N. Farnum and J. Dugald White of New York City; treasurer and assistant secretary, James A. Turnbull of Hartford; secretary and assistant treasurer, T. W. Moffat of New York City; directors, Loring N. Farnum, George de B. Green of New York, T. W. Moffat, Walter P. Schwabe, John E. Whinery of New York, J. Dugald White and William F. Williams of New York.

Panel Carries Steam Line Controls

FOR REMOTE CONTROL of steam lines, a new and interesting "twist" is shown in the accompanying photograph. The mimic busses and nameplates shown on the black panel are of polished copper. The busses represent steam lines and the nameplates are engraved with the size of pipe to a particular boiler, size of pipe to a particular turbine unit or the location of valves. Pushbutton stations are used only to close valves, each being in parallel with the closing buttons of another pushbutton station remote from the panel. The "open" control is located at the remote pushbutton station.



PUSHBUTTONS ON PANEL CONTROL VALVES AND INDICATING LAMPS SHOW OPEN STEAM LINES.

Each group of pushbuttons has three buttons. The topmost button controls the valve which feeds a high pressure steam line to a unit, the lowest button controls the valve feeding low pressure steam to the same unit and the middle button is a master by means of which each of the two valves can be closed. As the two valves in question are on steam lines of different pressure, both cannot be open at the same time, one always being closed. The master pushbutton will close the open valve, no matter which one it may be. By noting the red indicating lamps that are lit, it is possible, with this panel, to trace any open steam line from the boiler to the turbine unit. This panel was designed by General Electric Co. for use by the Chapman Valve Mfg. Co.

N.E.L.A. Power Survey, Great Lakes Division, Is Completed

ONE OF THE MOST thorough and painstaking investigations of the power resources and requirements of the states bordering Lake Michigan has just been completed by the Power Survey Committee of the N. E. L. A. The results of this survey are incorporated in an 84-page illustrated report now available.

This study, conducted as an activity of the Great Lakes Division of the N. E. L. A., evidences a recognition on the part of the electricity supply industry of its obligation to serve the public as completely and as economically as possible. The present high development of the industry is due to earnest and intelligent work in the past; and the continued endeavor to plan wisely for the future has now prompted this study in the Great Lakes region.

An idea of the scope of the report and of what the investigation included may, perhaps, best be conveyed by a brief synopsis.

Following certain preliminary sections which include a definition of the term superpower, the report opens with a statement of the accomplishments of superpower.

This section is devoted first to a description of the growth of electricity supply systems, their economic and social significance and the development of large systems and regional interconnections. Next, under the head "Stages of Superpower" the three classes of transmission service are described and the progressive transitions from one stage to another shown. Under improvements in service and trend of costs, are outlined the standards of quality service rendered possible by superpower and figures are presented which show how the cost of electric power has steadily decreased in spite of the general increase in living costs.

Economics of electricity supply are discussed in considerable detail, taking up water power developments, mine-mouth stations, relation between cost of production and cost of delivery and the better utilization of the components of coal.

Under the headings, "Present Conditions" and "Estimated Conditions in 1950," are given figures in regard to population, advance of industrial power, available locations, power resources, transmission lines, railroad electrification and other related economic conditions.

Miscellaneous Related Subjects which forms the next section treats, electricity in agriculture, right-of-way needs and practice, interconnection and joint operation, interconnection with the iron and steel industry, internal combustion engines, financing of electricity supply companies, and the place of the electricity-supply industry in national defense.

At the end of the report three appendices are listed, the first of which describes the trend of engineering in steam central stations, the second, the Federal Water Power act and third, the method of rating rivers.

On the whole, the report is an admirable piece of work and one that will not only be of great value to the industry but should be of interest to the general public. As a privately owned but publicly regulated industry, the public has a right to know whether or not the power resources are being utilized wisely and efficiently. While it is improbable that a report such as this will find its way into the hands of the general public, much of the information in it will undoubtedly be given to the public in one form or another.

Feather River Power Co. Orders Hydro Equipment

ORDERS HAVE BEEN PLACED by the Feather River Power Co. for powerhouse equipment to be installed in its Buck's Creek plant, where water will be utilized under 2350 ft. effective head. The hydraulic equipment is to be designed, built and installed by the Pelton Water Wheel Co. of San Francisco and will consist of two 35,000-hp. double-overhung, impulse turbines, complete with governor actuators, oil pressure system, hydraulic cylinder-operated gate valves and other auxiliaries. Two impulse wheels of 450-hp. capacity each will also be furnished for driving the exciter units.

Each turbine will be direct-connected to a 25,000-kv.a. generator, these to be furnished by the General Electric Co., whose contract covers all the electrical equipment for this plant. The entire plant output will be purchased by The Great Western Power Co. of California. R. C. Storrie & Co. is general contractor for the Buck's Creek development and the contracts with the turbine and electrical manufacturers require that this company take complete charge of installation work, turning the equipment over when ready to take on commercial load.

Northern States Power Co. Buys Jim Falls

NORTHERN STATES POWER CO. HAS PURCHASED from the Chippewa Power Co. the Jim Falls hydro-electric plant on the Chippewa River in Wisconsin, according to an announcement by R. F. Pack, vice-president and general manager of the Northern States company. The Jim Falls plant, which has a capacity of 14,400 kw., is an important unit in the interconnected power system of Northern States Power Co., which embraces power sources and transmission systems in six states of the central northwest—Minnesota, Wisconsin, North Dakota, South Dakota, Iowa and Illinois. Northern States Power Company now has 27 hydro-electric plants and 25 steam electric plants—a total of 52 power sources having installed generating capacities of 447,562 hp.

Forged Steel Valves for 1200-lb. Pressure

RECENTLY, Manning, Maxwell & Moore, Inc., placed on the market a new line of Hancock forged steel valves in globe pattern, sizes ½ to 2 in. for service at 1200 lb.

In the present design the packing nut has a complete thread bearing all around the yoke which takes away all tendency for the pressure on the packing gland to be one sided. The valve stem, except at its extreme end, which can easily be cleaned and oiled, is entirely covered, as is also the bonnet thread which keeps dirt and scale off the thread. All the dimensions, especially the flanged valves, are to the proposed 600-lb. standard, which is now in general use by manufacturers.

Maine Engineers Favor Exportation of Power

THE MAINE ASSOCIATION of Engineers, in a recent session at Portland, Me., voted unanimously in favor of abolition of the state law prohibiting the exportation of power beyond the state limits. Scores of other commercial and civic bodies have adopted similar resolutions. An exception to the law was made by the Legislature, following

a referendum vote of the state, in the case of the Dexter Cooper development at Passamaquoddy Bay. Now it is proposed to abolish the law. It will be recalled that the New England Industries survey made 2 yrs. ago, pointed out the vast possibilities of development of hydro-electric power in Maine, sufficient to supply the entire Eastern seaboard without disturbing the natural beauty of Maine's streams.

Virginia Power Utilities Expand

A. E. Fitkin & Co., 165 Broadway, New York, operating electric light and power utilities, has formed a new holding company to consolidate its properties in Virginia, to be known as the Virginia Public Service Corp. The new company has just acquired the Southside Virginia Power Co., operating hydro-electric power plants in the south central part of the state, and will consolidate with its other state utilities, including the Alexandria Light & Power Co., Virginia Western Power Co., Virginia Northern Power Co. and the Newport News & Hampton Railway, Gas & Electric Co. Plans are under way for extensions and improvements in the present power facilities in the different localities, including transmission line construction.

News Notes

The "Flexitallic" Gasket Co., Camden, N. J., announces that it has just opened an office in Chicago with E. H. Bolton in charge at 123 W. Madison St.

The Uvalde Rock & Asphalt Co., Uvalde, Tex., is installing a new 880-hp. Ingersoll-Rand oil engine, direct connected to the generator and Ingersoll-Rand compressors.

The Texas Central Power Co., San Antonio, Tex., has recently purchased the light, water and ice plants at Goliad, Tex. Leon Burgner is local manager for the company.

The Foxboro Co., Inc., Foxboro, Mass., announces the removal of its Chicago office, in charge of C. H. Roessner, to Rooms 204 to 206, St. Clair Bldg., 154 E. Erie St., Chicago, Ill.

Homestead Valve Mfg. Co., Inc., announces that after April 1 the Marine Specialty Co., 208 So. Peters St., New Orleans, La., will act as its representative in that district, handling a complete line of Homestead valves.

The New York Edison Co., 130 East Fifteenth St., has filed plans for the erection of a seven-story power station and operating building at 80-82 West Fourteenth St., estimated to cost $1,000,000. Thomas E. Murray, Inc., 55 Duane St., New York, is engineer.

The Federal Government has awarded a contract to the Byllesby Engineering & Management Corp., Chicago, Ill., for the construction of its proposed dam on the Ohio River at Louisville, Ky., forming a portion of the plan to establish a 9-ft. stage of water in the Ohio River for navigation from Pittsburgh, Pa., to Cairo, Ill. The dam will be of navigation and power type, 1½ mi. long, and will be constructed at a cost of $2,056,187, the bid of the company noted. The Louisville Hydroelectric Co., a subsidiary of the Louisville Gas & Electric Co., will carry out a hydro-electric power project at the new dam, and this work, also, will be handled by the Byllesby organization. The station will be about 500 ft. long and will be known as the Ohio Falls development; it will have an initial installation of 135,000 hp., and will cost close to $10,000,000, with transmission lines and power substations. It is expected to be completed in about 36 mo. The output will be used primarily by the parent organization for distribution in the Louisville district.

Announcement is made by the Boiler Engineering Co., 760 Broad St., Newark, N. J., that it is now manufacturing and selling the Canady combustion control system. J. F. Canady, inventor and former manufacturer of this device, has recently become associated with the Boiler Engineering Co.

Active construction work is being conducted by the Alabama Power Co., Birmingham, Ala., on its hydro-electric power project at Cherokee Bluffs, Ala., designed for an initial capacity of 135,000 hp. It is expected that the plant will be ready for service in the fall of this year.

Florida Light & Power Co., Miami, Fla., is planning an expansion program for 1926 to cost approximately $15,000,000. Three new steam power plants will be constructed, the largest, at Fort Lauderdale, of 65,000-hp. capacity. Existing plants will be extended and improved to increase the rating about 85,000 hp. and many new transmission lines will be installed.

The Organization of Lee and Clark has recently been incorporated, with offices at 549 W. Washington Blvd., Chicago, to take over the business conducted as a partnership under the name of The James T. Lee Co. James T. Lee is president and John O. Clark is vice-president of the new organization. The company specializes in hydraulic equipment, metal working machinery, pumps, pipe benders, flexible joints and the like.

An unusually large crane shipment was recently made by Whiting Corp., Harvey, Ill., which required 16 freight cars. It consisted of two electric traveling cranes, each crane having a main hoist of 200 t. capacity and an auxiliary hoist of 25 t. capacity; span, 58 ft.; vertical lift, 100 ft. The cranes were built for the New York Edison Co., New York (Thomas E. Murray, Inc., engineers) and are now being erected in the East River Station, New York.

The Oroville-Wyandotte Irrigation District has applied for a preliminary permit for a project on the South Fork of Feather River and tributaries, in Butte and Plumas Counties, Calif. Alternative schemes of development are proposed, one involving the construction of five power houses with appurtenant works, and the other involving the construction of three power houses with appurtenant works. About 74,625 hp. is proposed to be developed, for sale to one of the public utilities operating in northern California.

The Federal Power Commission, Washington, D. C., has issued a license for 50 yr. to Walter Cravens of Kansas City, Mo., for a power project on the Osage River in central Missouri, near the town of Bagnell. The project will consist of a concrete, gravity-type dam approximately 100 ft. in height, with the power house built integral four vertical turbo-generating units aggregating 125,000 kv.a. The developed power is to be used for public utility purposes in west central Missouri.

Books and Catalogs

BOTHERING BUSINESS—By H. A. Toulmin, Jr., Dayton, Ohio. In this small book is presented the author's review of the failings of the Federal Trade Commission and why its operation should be reformed. Also the defects of our patent system administration and how it works to stifle rather than to encourage invention.

Suggestion is made that to remedy the chief faults of the Federal Trade Commission activities:

1. Simplify procedure by taking away the powers of investigation and prosecution, putting these in the Department of Justice and letting the Commission sit as a court of judgment on complaints.
2. Let private quarrels alone to be handled in the courts and consider only broad questions of public policy.
3. Decentralize hearings to localities where the parties at interest are located.
4. No legal work to be done by staff attorneys.
5. Put the Commission under a responsible cabinet officer.

To remedy the patent situation, it is suggested that the number of examiners and clerks be increased and larger salaries paid; that the Commissioner be purely an executive officer; that adequate quarters be provided; that the systems of interferences and of classification of patents be simplified thus reducing labor, expense and delay.

FUEL ECONOMY AND SMOKE PREVENTION, by John B. C. Kershaw, third edition; 268 pages; 91 illustrations; 6 by 9 in.; cloth; price, $5; New York.

Having been written in England and describing, for the most part, British practice, American power plant operators will find little interest in the descriptions of foreign equipment. Designers, however, may find the study of this apparatus quite profitable. There are 15 chapters with both name and subject indexes.

THE HANDBOOK OF THE U-RE-LITE and the Handbook of the I-T-E Circuit Breaker are being distributed by the Cutter Co., Philadelphia, Pa. The I-T-E is an air break carbon circuit breaker, adapted to a wide variety of services. The first part of the handbook discusses methods of application and the following sections give details of the various types, together with price lists. The U-Re-Lite is a small circuit breaker enclosed in steel armor designed to replace fused knife switches. Type, sizes and prices of these are given, together with many photographs of installations.

AS A RESULT OF SOME RESEARCH work recently carried out at its Research Laboratory at Cornell University by The Leather Belting Exchange Foundation, a pamphlet entitled "A Report of Experiments to Determine the Relative Transmitting Capacity of Belts on Vertical, Angular and Horizontal Drives" by R. F. Jones, has just been issued. The report describes first the apparatus and methods used in testing horizontal and vertical belt drives, these being compared with tests on belts run at 45 deg. and 67½ deg. with the horizontal. Five different belts were used, two being high capacity leather belts and three substitute belts of lower transmission capacity. A total of 88 tests were made and the results are discussed and compared, several tables and diagrams being given to show the results. Copies of the report will be sent free of charge to engineers, plant executives and educational institutions upon application to The Leather Belting Exchange, 119 South Fourth St., Philadelphia, Pa.

"BRIXAVER" is the title of a folder, recently issued by the Inland Fire Brick Co. of Cleveland, O., describing the uses of Brixaver refractory cement.

BARCO MFG. CO., Chicago, Ill., has recently issued two interesting catalogs, No. 201 dealing with Barco flexible joints for oil, steam, air and gasoline, water and other fluids, gases and liquids where a flexible conveyor is required and No. 304 describing the Barco balanced and lubricated plug valve.

AN ATTRACTIVE 32-PAGE illustrated booklet on the subject of portable instruments has recently been published by the General Electric Co., Schenectady, N. Y. This booklet which is known as Bulletin GEA-158, supersedes Bulletin 46044, and is devoted to descriptions and characteristics of both direct and alternating current portable measuring instruments.

"NOTES ON MOVING COIL GALVANOMETERS" is the subject of Note Book No. 2, recently issued by Leeds & Northrup Co., 4901 Stenton Ave., Philadelphia, Pa. This is a 48-page book which deals in a scientific way with the subject and will be found extremely valuable to the engineer who wishes to become more familiar with electric instruments of this type.

"COMMON SENSE in Steel Dollars" is the title of an attractive booklet, recently issued by the Heintz Mfg. Co., Philadelphia, Pa., which deals with "Steelprest" products and their manufacture. The booklet is illustrated with halftone engravings made from shop photographs which give the readers a comprehensive idea of the processes through which the steel goes in the process of manufacturing "Steelprest" products.

"STORAGE OF BULK Materials with Power Scrapers" is the title of catalog No. 8, recently issued by Sauerman Bros., Inc., of Chicago. This catalog gives a brief review of the subject, including detailed description of Sauerman power drag scraper equipment and illustrations showing how these installations are meeting the demands of industry. The catalog is well illustrated with halftones and line drawings which are an aid in solving material handling problems.

DETROIT multiple retort underfeed stokers are described in a bulletin just issued by the Detroit Stoker Co., Detroit, Mich. Illustrations bring out many special features, such as the level fuel bed and the method for controlling movement of the fuel throughout the entire process of combustion. The applications shown cover a wide range of operating conditions and include installations with preheated air, the burning of wood refuse with coal at high ratings, use of the stokers for burning Indiana and Illinois coal, etc.

AMERICAN LOCOMOTIVE CRANES for handling materials with hook, grab bucket or magnet are described in a well arranged and splendidly illustrated book issued by American Hoist & Derrick Co., St. Paul, Minn. The closeup views of details of the revolving mechanism, the gib rings used instead of a single steel king pin and the various details of construction of the car, brakes, power plant and so on, are especially interesting. Photographs of interesting applications of the crane for handling materials of all types are shown, as used in handling coal, scrap iron, lumber, stone and other materials.

Sparks from the Advertising Pages

Where Buyers and Sellers Meet

Competition and Simplification

Free and unlimited competition has furnished the incentive which has brought the human race to its present stage of development. Without competition we would surely be generations behind our present status.

Invention of new methods of doing things and of new machines and appliances with which to do them have ever been the outcome of man's competitive existence.

In the times and places where the spirit of freedom is given greatest opportunity to flourish, there improvements in the necessities and conveniences of life have most rapidly developed.

While this is true in actual practice it is equally true that competition leads to useless duplication of effort and, beyond a certain point, to vast economic loss.

This country has seen the world's greatest development of machinery and equipment for the generation and application of power to all kinds of human needs.

This, in turn, led to an enormous number and variety of manufactured products.

In consequence thereof the time came when every industry, business and individual was paying an extraordinarily high price for doing business because of the great waste that existed from too much competition.

In this situation there were two great developments in American industry, one preceding the other, but largely overlapping.

First came the era of so-called trusts when excessive competition was overcome to some extent by manipulation, purchase and consolidation into as near monopolies as it was possible to effect in a country that was politically self-governed.

Following this, much legislation was passed against monopoly largely without results except those of spectacular legal cases that had little effect on actual economic conditions.

At about this time began the development of another force destined to produce a profound effect on human existence.

This force was the mass distribution of ideas by means of the printed page or what is known as modern advertising.

A glance back over the past few years shows how quantity distribution of ideas and of products has developed together until today there is scarcely an industry or a business in which both are not necessary to the most economical operation.

Very soon it was discovered that advertising was a power that worked both ways. It immediately enabled small concerns to spring up and flourish in competition with the great combinations of capital and manufacturing facilities.

On the other hand advertising exercised a tremendous force toward standardization and simplification of styles, patterns, sizes and shapes of products. It enabled manufacturers to crystallize the tastes of people and to discover what those tastes were and plan their manufacturing and distributing activities to most economically meet them.

Advertising and power are the two great forces that have placed every convenience of life from electric lights to canned soup in the homes and at the disposal of a greater proportion of the American people than was ever enjoyed by any people in any part of the world before.

Government again has taken cognizance of this new order of things and the work of Mr. Hoover has furthered simplification of business and industry and the prevention of economic waste.

Advertising itself has discovered its fundamental laws, set standards for most economical operation and reached a height of efficiency and serviceability that may be compared to the best practice in power generation.

Just as POWER PLANT ENGINEERING employs every reasonable means to further the cause of better power generation so, in its advertising pages, it endeavors to maintain the highest accepted standards of practice to the end that its readers may find every part of this publication worthy of their confidence and of the greatest possible helpfulness.

Machinery, Equipment and Supplies Used In The Production and Transmission of Power

Under the heading of each product listed will be found the names of the manufacturers of that product. The index to advertisers, next to the back cover, gives the page numbers on which the manufacturers' descriptive advertisements appear.

AIR COMPRESSORS.
Allis-Chalmers Mfg. Co., Milwaukee, Wis.
Bethlehem Shipbuilding Corp., Bethlehem, Pa.
Dean Bros. Co., Indianapolis.
De Laval Steam Turbine Co., Trenton, N. J.
Gardner Governor Co., The, Quincy, Ill.
Ingersoll-Rand Co., New York.
Murray Iron Works Co., Burlington, Iowa.
Nordberg Mfg. Co., Milwaukee.
Worthington Pump & Machinery Corp., New York, N. Y.
Yeomans Bros. Co., Chicago, Ill.

AIR FILTERS.
Cooling Tower Co., Inc., New York.
Spray Engineering Co., Boston.

AIR WASHERS.
Badger & Sons Co., E. B., Boston, Mass.
Buffalo Forge Co., Buffalo.
Cooling Tower Co., Inc., The, New York.
Spray Engineering Co., Boston.

ALARMS, HIGH AND LOW WATER.
Hills-McCanna Co., Chicago.
Huyette Co., Inc., The Paul B., Philadelphia, Pa.
Northern Equipment Co., Erie.
Reliance Gauge Column Co., Cleveland, Ohio.
Wright-Austin Co., Detroit.

ARCHES, BOILER COMBUSTION.
Betson Plastic Fire Brick Co., Inc., Rome, N. Y.
Brady Conveyors Corp., Chicago.
Burke Engineering Co., Holland, Mich.
Detrick Co., M. H., Chicago.
Harbison - Walker Refractories Co., Pittsburgh, Pa.
Hofft Co., The M. A., Indianapolis, Ind.
Liptak Fire Brick Arch Co., Mexico, Mo.
McLeod & Henry Co., Troy, N. Y.
Obermayer Co., The S., Chicago.
Plibrico Jointless Firebrick Co., Chicago, Ill.
Queen's Run Refractories Co., Inc., Lock Haven, Pa.
Quigley Furnace Spec. Co., New York.

ASH AND COAL BINS.
Frederick Iron & Steel Co., Frederick, Md.

ASH BIN GATES AND DOORS.
Allen-Sherman-Hoff Co., The, Philadelphia, Pa.
Brady Conveyors Corp., Chicago.
Frederick Iron & Steel Co., Frederick, Md.
Hagan Co., George J., Pittsburgh.

ASH HANDLING SYSTEMS.
Allen-Sherman-Hoff Co., The, Philadelphia, Pa.
Brady Conveyors Corp., Chicago.
Conveyors Corp. of America, Chicago.
Detrick Co., M. H., Chicago.
Frederick Iron & Steel Co., Frederick, Md.
Hagan Co., George J., Pittsburgh.
Link-Belt Co., Chicago, Ill.
Stephens-Adamson Mfg. Co., Aurora, Ill.
Webster Mfg. Co., The, Chicago.

ASH TANKS.
Brady Conveyors Corp., Chicago.
Conveyors Corp. of America, Chicago.
Hagan Co., George J., Pittsburgh.

BEARING METAL.
Strong, Carlisle & Hammond Co., The, Cleveland, Ohio.

BEARINGS, ROLLER.
Timken Roller Bearing Co., The, Canton, O.

BELT CONVEYORS.
Stephens-Adamson Mfg. Co., Aurora, Ill.
Webster Mfg. Co., The, Chicago.
Weller Mfg. Co., Chicago.

BELT DRESSING.
Cling-Surface Co., Buffalo, N. Y.
Dixon Crucible Co., Jos., Jersey City, N. J.
Standard Oil Co. (Indiana), Chicago, Ill.
Stephenson Mfg. Co., Albany.

BELT LACING.
Bristol Co., The, Waterbury.

BELTING
Quaker City Rubber Co., Phila.
United States Rubber Co., New York, N. Y.

BELTING, SILENT CHAIN.
Link-Belt Co., Chicago, Ill.
Morse Chain Co., Ithaca, N. Y.

BLOWERS, FAN AND FURNACE.
Air Preheater Corp., The, New York.
Buffalo Forge Co., Buffalo.
Coppus Engineering Corp., Worcester, Mass.
De Laval Steam Turbine Co., Trenton, N. J.
Ingersoll-Rand Co., New York.
Vulcan Soot Cleaner Co., Du Bois, Pa.
Webster, Howard J., Philadelphia, Pa.
Wing Mfg. Co., L. J., New York.

BLOWERS, FORCED DRAFT
Sturtevant Co, B. F., Boston.

BOILER SEAM PROTECTORS.
National Boiler Protector Co., Dayton, Ohio.

BOILER SETTING CEMENT.
Betson Plastic Fire Brick Co., Rome, N. Y.
Botfield Refractories Co., Philadelphia, Pa.
General Refractories Co., Philadelphia, Pa.
Harbison - Walker Refractories Co., Pittsburgh, Pa.
Huyette Co., Inc., The Paul B., Philadelphia, Pa.
Obermayer Co., The S., Chicago.
Plibrico Jointless Firebrick Co., Chicago, Ill.
Queen's Run Refractories Co., Inc., Lock Haven, Pa.
Quigley Furnace Spec. Co, New York

BOILER SETTINGS.
Betson Plastic Fire Brick Co., Rome, N. Y.
Botfield Refractories Co., Philadelphia, Pa.
General Refractories Co., Philadelphia, Pa.
Harbison - Walker Refractories Co., Pittsburgh, Pa.
McLeod & Henry Co., Troy, N. Y.

To Find the Manufacturers' Advertisements of Products Listed Here, See Index Page 172

BLOWERS, PORTABLE.
Buffalo Forge Co., Buffalo.
Clements Mfg Co., Chicago, Ill.
Sturtevant Co., B. F., Boston.

BLOWERS, TUBE.
Bayer Co., The, St. Louis.
Diamond Power Specialty Corp., Detroit.
Marion Mach., Fdry. & Supply Co., Marion, Ind.
Sherwood Mfg. Co., Buffalo.

BLOWERS, TURBINE.
Moore Steam Turbine Corp., Wellsville, N. Y.
Terry Steam Turbine Co., The, Hartford, Conn.
Wing Mfg. Co., L. J., New York.

BOILER BAFFLES.
Betson Plastic Fire Brick Co., Rome, N. Y.
McLeod & Henry Co., Troy, N. Y.
Power Plant Efficiency Co., Indianapolis.
Quigley Furnace Spec. Co., New York.

BOILER CAP CLEANERS.
Lagonda Mfg. Co., Springfield, Ohio.

BOILER CASINGS.
Walsh & Weidner Boiler Co., The, Chattanooga.

BOILER COMPOUNDS.
Botfield Refractories Co., Philadelphia, Pa.
Dearborn Chemical Co., Chicago.
Hawk-Eye Compound Co., Blue Island, Ill.
McLeod & Henry Co., Troy, N. Y.
Paige & Jones Chem. Co., New York.

BOILER COMPOUND FEEDERS.
Hills-McCanna Co., Chicago, Ill.

BOILER FEEDWATER PURIFYING APPARATUS.
Griscom-Russell Co., New York.
Paige & Jones Chem. Co., New York.
Permutit Co., The, New York.
Power Plant Specialty Co., Chicago, Ill.
Scaife & Sons Co., Wm. B., Pittsburgh.

BOILER FRONTS.
McLeod & Henry Co., Troy, N. Y.

BOILER MOUNTINGS.
Lunkenheimer Co., Cincinnati.
Obermayer Co., The S., Chicago.
Plibrico Jointless Firebrick Co., Chicago, Ill.
Queen's Run Refractories Co., Inc., Lock Haven, Pa.
Quigley Furnace Spec. Co., New York.
Walsh & Weidner Boiler Co., The, Chattanooga.
Webster, Howard J., Philadelphia, Pa.

BOILER SKIMMERS.
Sims Co., The, Erie, Pa.

BOILER TUBE CLEANERS.
Lagonda Mfg. Co., Springfield, Ohio.
Liberty Mfg. Co., Pittsburgh.
Pierce Co., The Wm. B., Buffalo, N. Y.
Roto Co., The, Hartford, Conn.

BOILER TUBES.
Babcock & Wilcox Tube Co., The, Beaver Falls, Pa.
Bethlehem Steel Co., Inc., Bethlehem, Pa.
Murray Iron Works Co., Burlington, Iowa.
Scully Steel & Iron Co., Chicago.

BOILER WALL COATINGS.
Botfield Refractories Co., Philadelphia, Pa.

BOILERS.
Babcock & Wilcox Co., New York.
Badenhausen Corp., Cornwells Heights, Pa.
Bigelow Co., The, New Haven.
Brownell Co., The, Dayton, Ohio.
Casey-Hedges Co., The, Chattanooga, Tenn.
Connelly Boiler Co., The D., Cleveland, Ohio.
Connery & Co., Inc., Philadelphia.
Edge Moor Iron Co., Edge Moor, Del.
Erie City Iron Works, Erie, Pa.
Freeman Mfg. Co., Racine, Wis.
Heine Boiler Co., St. Louis.
Kingsford Fdry. & Mach. Co., Oswego, N. Y.
Murray Iron Works Co., Burlington, Iowa.
Nuway Boiler & Engineering Co., Chicago.
Union Iron Works, Erie, Pa.
Walsh & Weidner Boiler Co., The, Chattanooga.
Webster, Howard J., Philadelphia, Pa.
Wickes Boiler Co., The, Saginaw, Mich.

BOOKS AND SCHOOLS.
Audel & Co., Theo., New York.
McGraw-Hill Book Co., Inc., New York.

BREECHINGS.
Connery & Co., Inc., Philadelphia.
Littleford Bros., Cincinnati.

BRUSHES, DYNAMO & MOTOR.
Dixon Crucible Co., Jos., Jersey City, N. J.

BRUSHES, GRAPHITE.
Dixon Crucible Co., Jos., Jersey City, N. J.

BRUSHES, WIRE.
Pilley Pkg. & Flue Brush Mfg. Co., St. Louis, Mo.

BUCKET ELEVATORS.
Brady Conveyors Corp., Chicago.
Link-Belt Co., Chicago, Ill.
Webster Mfg. Co., The, Chicago.

BUCKETS, CLAM SHELL.
Orton Crane & Shovel Co., Chicago.

BUCKETS, COAL HANDLING.
Orton Crane & Shovel Co., Chicago.

CARRIERS, PIVOTED BUCKET.
Webster Mfg. Co., The, Chicago.

CASTINGS.
Bethlehem Steel Co., Inc., Bethlehem, Pa.
Erie City Iron Works, Erie, Pa.
Fuller-Lehigh Co., Fullerton, Pa.
Hills-McCanna Co., Chicago, Ill.
International Nickel Co., New York.
Neemes Fdry, Inc., Troy, N. Y.

CEMENT, FURNACE.
Betson Plastic Fire Brick Co., Rome, N. Y.
Botfield Refractories Co., Philadelphia, Pa.
General Refractories Co., Philadelphia, Pa.
Harbison - Walker Refractories Co., Pittsburgh, Pa.
McLeod & Henry Co., Troy, N.Y.
Obermayer Co., The S., Chicago.
Plibrico Jointless Firebrick Co., Chicago, Ill.
Queen's Run Refractories Co., Lock Haven, Pa.
Quigley Furnace Spec. Co., New York.

CEMENT GUNS.
Cement - Gun Co., Inc., The, Allentown, Pa.

CEMENT, HIGH TEMPERATURE.
Botfield Refractories Co., Philadelphia, Pa.
General Refractories Co., Philadelphia, Pa.
Harbison - Walker Refractories Co., Pittsburgh, Pa.
McLeod & Henry Co., Troy, N. Y.
Obermayer Co., The S., Chicago.
Plibrico Jointless Firebrick Co., Chicago, Ill.
Quigley Furnace Spec. Co., New York.

CEMENT, IRON.
Smooth-On Mfg. Co., Jersey City, N. J.

CHAIN WHEELS.
Babbitt Steam Specialty Co., New Bedford, Mass.

CHAINS, DRIVE.
Link-Belt Co., Chicago, Ill.
Morse Chain Co., Ithaca, N. Y.

CHIMNEYS.
American Chimney Corp., New York, N. Y.
Bigelow Co., The, New Haven.

CLEANERS, BOILER TUBE.
General Specialty Co., The, Buffalo, N. Y.
Lagonda Mfg. Co., Springfield, Ohio.
Liberty Mfg. Co., Pittsburgh, Pa.
Pierce Co., The, Wm. B., Buffalo, N. Y.
Roto Co., The, Hartford, Conn.

CLEANING COMPOUNDS.
Dearborn Chemical Co., Chicago.

COAL AND ASH HANDLING MACHINERY.
Allen-Sherman-Hoff Co., The, Philadelphia, Pa.